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CONRAD HILTON HOTEL, CHICAGO, ILL.
SEPTEMBER 19, 20, 21, 1983

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Official Discussion Record of 44th Annual Meeting

LMOA

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MONDAY, SEPTEMBER 20, 1982

TUESDAY, SEPTEMBER 21, 1982

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MONDAY MORNING SESSION
September 20, 1982

NELSON A. BUSKEY
PRESIDENT
Asst. General Manager - Locomotive
Chessie System
Huntington, WV 25704

MONDAY MORNING SESSION
September 20, 1982

The 1982 Annual Meeting of the Locomotive Maintenance Officers Association, held on September 20-22, 1982 at the Conrad Hilton Hotel, Chicago, Illinois, convened at 9:20 a.m.

MR. L. J. KAST: Good morning, ladies and gentlemen. I am L. J. Kast, President of the Air Brake Association. I am with the Chessie System. It is my great pleasure to welcome all of you to this annual conference. It is very good to see everyone here at this time. We are about to go forward with formal and informal meetings, with the objective of improving our individual skills for our pleasure as well as for the enhancement of our great transportation industry. This is a continuation of annual meetings which began nearly 100 years ago.

As is proper and has been established by tradition, will you now rise for the invocation, to be given by the Reverend Calvin W. Markham, Senior Pastor, Village Presbyterian Church, Northbrook, IL.

REVEREND CALVIN W. MARKHAM: Almighty God, we stand before You in reverence this morning, with a sense of awesome wonder of this universe that You have created, and this earth especially upon which we dwell.

Our own nation is of particular concern to us. This morning we take a moment to reflect upon the majesty of this land, its mountains, the valleys, the plains, the lakes, the seashores, the deserts, the forests, the prairies, all that grows thereupon and all that is mined from the earth. These things are Your gifts to us.

In the movement of all the raw materials and the manufactured products from place to place, how dependent we are day by day for what we eat, what we wear, and what we use that has been transported across our mighty land. Not only material and physical things, but the movement of people, one of the richest things in our heritage. One of the things we recognize in making possible the greatness of our nation and the moving of its people is the role of the railroad.

This morning we stand in reverence before the creative mind of man that has been made possible because we have been made in Your image, in the sense that we can think, plan and devise. And yet the majesty of this great rail system is not in these material things but is in the men and women who created them, who use them, who benefit from them.

And so this morning we pray for those who are assembled here for the express purpose of increasing their skills, not just for the bettering of themselves but for the better serving of mankind.

This morning we are especially aware of the vital role of our transportation system as it relates to the rails, for not only in this great metropolitan area of Chicago are we clogged and bound, keeping at a congested crawl, but in all of of the other metropolitan areas of America this morning there is this similar situation and experience.

We pray that You will give wisdom to those who are in negotiation. Certainly I stand here this morning not knowledgeable of what is right and what is wrong, therefore voicing no opinion to You, but praying for this one thing, Almighty God, that in the minds of all in negotiation there will be a sense of what is fair, what is right, what is Christlike, what is the spirit and the character that should affect my attitude, my speaking, my conduct, my role. There are certainly those who sit at tables this morning wielding great power, almost immeasurable influence over all of our lives directly and indirectly. I pray that there will be that sense of consideration for what is good for my brother, what is good for our nation. And then we will settle the question of, in the context of these things, what we can do that is just and right in Your sight.

Bless, I pray, the leadership of this assembly, those who are here, those who have been elected by their peers to be their leaders. May they use this role of leadership in such a way that all who are seated before them will sense that they have chosen wisely and have done well. May there be the spirit of give-and-take and seek-and-find and serve in the minds and hearts of each and all who compose this assembly this day.

May those who have come to be the keynote speaker and other speakers throughout these days not only bring their experience and their skill but their minds and hearts open to Divine directive, and may they receive it for Your glory, for the good of all concerned. It is my prayer in the Name of Jesus Christ. Amen.

MR. KAST: Thank you, Reverend Markham. Our following of your words will lead us on to a much better conference.

It is our privilege again to have a joint meeting for our opening. Because our Associations have a common objective, that of operating trains at a profit, it is very fitting that we jointly meet to hear the remarks of a leader in our industry. However, before our keynote speaker is introduced I would like you to meet the gentlemen here at the speaker's table. As their names are called I will ask these individuals to stand. Please withhold your applause until all have been introduced.

First, on my left is Mr. Nelson Buskey, President of the LMOA. He serves the Chessie System as Assistant General Manager - Locomotive Maintenance.

Next to Mr. Buskey is Mr. Jack Roberts, who is also on our Chessie System. He is Assistant Superintendent-Locomotive Operation. Mr. Roberts is Second Vice President of the Railway Fuel and Operating Officers Association. He is here representing the President, Mr.

Baker, who is out today probably somewhere on a train.

Then we have Mr. Hector P. Zakaib, Mechanical Superintendent of CTTX. Mr. Zakaib is Vice President of the Car Department Officers Association, substituting this morning for its President, Mr. Don Roderick, who is also away from us today because of our present labor situation.

On my left is Mr. W. A. Cyr, Chief of Motive Power and Equipment on the Canadian National Railway. He is chairman of the Committee of the Coordinated Associations.

Next we have Mr. R. A. O'Connor, who is President of the Railway Supply Association.

Directly to my right is Mr. Collinson. Mr. Collinson is our keynote speaker this morning. I will not ask him to stand just yet because I want to elaborate on the introduction of Mr. Collinson.

Gentlemen, let's give these gentlemen a hand. [Applause]

Mr. Collinson is President and Chief Executive Officer of the Chessie System Railroads. These are the Chesapeake & Ohio, the Baltimore & Ohio, the Western Maryland, and affiliated lines. He became President of the C&O and B&O on November 16, 1978, and was named President of the Western Maryland on February 9, 1982. He was named Chief Executive Officer of all the railroads on April 21, 1980.

He is a fourth-generation railroad man, who came up through the ranks of the operating department. Before his election as President he was Executive Vice President in charge of operations.

Mr. Collinson was born in Pittsburgh in the summer of 1926. He graduated from Cornell University with a Civil Engineering degree in 1946. He joined the B&O shortly after graduation as an engineering assistant in Pittsburgh, Pennsylvania. He held various positions in the Engineering Department of the B&O, and became Chief Engineer in 1964. In 1966 he was promoted to Chief Engineer - Maintenance for both the C&O and B&O Railroads. In April, 1971 Mr. Collinson became General Manager, Chief Engineer, for Chessie, the position he had held until his promotion to Vice President for Operations and Maintenance in September, 1973.

Mr. Collinson is a Director of CSX Corporation, the Richmond, Fredericksburg and Potomac Railroad, the Monumental Corporation and the National City Corporation, the holding company for the National City Bank of Cleveland. He is a member of the Board of Directors of the Association of American Railroads.

The Chessie System railroads are a unit of CSX Corporation which was formed through the merger of the Chessie System, Inc. and Seaboard Coastline Industries in November, 1980. Mr. Collinson. [Applause]

MR. JOHN T. COLLINSON: Thank you, Larry. It is indeed a pleasure for me to be here today during a somewhat trying time in our industry. I recognize that the number of empty seats in the auditorium today are certainly not due to a lack of interest in the proceedings of these organizations but to the fact that I myself and a few other executive officers around the country, I am sure, assigned the men to other duties because of the situation we face this morning.

[The audience arose and applauded]

The title of my remarks — "Railroads Unlimited" — may seem untimely in light of the current condition of the economy and its effect on our industry and its partners. Taking a short-range view, one could say that the only things that appear unlimited for railroads right now are problems and challenges.

Without making light of the situation, I'm sure you are aware that there have been many other times in the history of the railroad industry when problems loomed even larger and solutions to them seemed nearly unattainable. Since 1828, when the industry was born with the founding of the Baltimore and Ohio, there have been a number of trying periods leading observers at those times to conclude that the age of the railroads was ending. In every case, we recovered and, what is more important, went on to establish, in partnership with the supply industry, remarkably productive advances in technology, operations and service.

In my own experience there have been a few of these trying times: The late '40s and early '50s, then

JOHN T. COLLINSON
President and Chief Executive Officer
Chessie System

the latter years of the same decade and the first years of the next — all periods of economic trial and wrenching change. Yet those same periods saw a complete revolution in motive power and freight car design, far-reaching advances in signal and communications technology and the literally earth-shaking introduction of computer science. There occurred vast alterations in the very philosophy of transportation and lately a physical restructuring of the railroad industry through mergers, such as that of Chessie and Family Lines into CSX Corporation. Every time someone has pronounced the railroads dead and lighted the candles, we have come to and gotten back into the game.

Someone once called the broadway stage "The Fabulous Invalid." That's a good name too for the railroads over the past 30 years. Despite current economic problems, I suggest we will in the near future earn the label of "fabulous," no longer an invalid.

The era of the '80s is, in a way, similar to those preceding it. Once again, it offers an interesting mix of challenges and opportunities. The difference this time is that the opportunities are brighter and offer a far greater return. In that sense, then, the outlook for railroads is truly unlimited, providing that all of us involved with the railroad industry take advantage of each and every opportunity as we never have before.

The challenges and problems presented in this decade include some familiar old faces, as well as a couple of awesome newcomers. First in line stands our old and long-lived enemy: Revenue Inadequacy. This is a long-standing dilemma for our railroads. For a variety of reasons, mostly beyond our control, we have never been able to earn an adequate return on investment. Railroad rates of return presently average about four to five percent — not very reassuring when interest rates have been at the 20 percent level.

In fact, among the nation's fourteen major industries, railroads stand in last place in this key measurement of financial adequacy. The problem is compounded because railroads, as you are well aware, are a most capital-intensive industry.

The rate-making relief afforded by the Staggers Act is going to provide an important part of the means to achieve revenue adequacy. However, as Hays Watkins, Chairman of our parent corporation, CSX, points out, the major contribution to a solution will be made through improving the efficiency of railroad operations, thereby enabling us to provide more and better transportation for our customers at a lower cost to us. Railroads already have a good record in operational efficiency; we just have to make it even better.

Another old-timer among our challenges is intermodal competition. We don't mind competing with other forms of transportation at all; in fact, we've gotten into some other modes ourselves. Competition, however, should be on an equal footing, in a private enterprise economy, with everybody paying his fair share of the bill. It isn't as if the problem isn't widely recognized. In fact, Traffic World magazine published an editorial on the subject:

"Rails pay for their own right of way," the magazine's editor wrote, "and so do the motor vehicles, though there is some dispute as to whether the latter pays in full measure . . . but waterway operators, including shippers, still are permitted to use free waterways deepened and maintained for them at public expense, even when, as the users are fond of saying, the waterways were originally provided by God. God does not, however, keep their channels deepened and clear, nor does He dig canals. Until the situation is taken care of, our transportation system will still be lopsided in its regulatory aspects."

As a railroader, I'm grateful for that kind of support of my industry's aims for intermodal equity. But I'm not very inspired by it. That editorial appeared in Traffic World's issue of September 14, Nineteen Forty — more than four decades ago. The problem is not only still with us, but it has assumed even greater proportions.

Another challenge on the intermodal front is a very formidable one — the coal slurry pipeline. Thirteen of these monsters are presently planned for the purpose of pumping a coal-and-water mixture from mines, largely in the west, to major consumers of coal, such as power plants. At the crux of the situation is the pipelines' demand for the right to exercise the power of federal eminent domain.

Slurry pipelines have so far been unable to build an impregnable case of public need, something the railroads were clearly able to do when they won the right of eminent domain in the nineteenth century. Railroads are particularly concerned about the slurry pipeline issue, since the pipelines seek to siphon away premium coal traffic — and only the high-volume part — which constitutes the most profitable part of the business of transporting coal.

Revenue inadequacy . . . intermodal unfairness . . . boondoggling pipelines are three of many challenges confronting our industry. However, they are certainly three of the largest and most threatening and, as such, they demand all of the attention our industry and its friends can muster.

However, if railroads face tremendous challenges, they also confront tremendous opportunities that offer a part of the response to those challenges. Foremost among them is the new atmosphere of deregulation generated by the Staggers Act. While that welcome legislation did not truly deregulate the railroads, it has given our industry over the two years of its life much greater freedom to operate, to compete and to solve our problems.

The Staggers Act's most outstanding facet is its basic recognition that railroads don't have to be as tightly regulated as they have been for more than a century. Railroads can now adjust the prices they charge for service in a much more timely way, responding, like any other free enterprise business, to changing conditions in the marketplace — and we are free to sign contracts.

Just how badly the old regulatory system damaged the railroads could be seen in the two years immediately preceding passage of the Act. Because of the regulatory lag in implementing general rate increases under the old system, railroads suffered enormous revenue losses. How much? In the twenty-four month period, the loss amounted to three and a third **billion** dollars. Think of how much equipment and appliances even half of that would have purchased.

While our pricing freedom is still closely controlled, we have already demonstrated that we are able to exercise that freedom in an innovative manner to everyone's benefit. The new contract rules railroads are authorized to make, for example, provide advantages in both price and service, making them doubly attractive.

Another golden opportunity for the railroads is a black one — I mean coal. The CSX Railroads are 100 percent bullish on coal's future and especially its future in this country. The use of coal by electric utilities will probably double by 1995, and we can see the beginning of that trend. In CSX Railroad territory, over the next four years, thirty-eight new coal-fired generating units will be completed. In the same period, it is expected that fully fifty-seven more plants now burning oil will be converted to coal.

Coal's markets overseas will also grow, with total exports exceeding 175 million tons by 1995. The capacity to meet that growth is already being assembled, with new export facilities being built or planned at Baltimore, Hampton Roads, Savannah, Charleston, Wilmington, Mobile, New Orleans and other Gulf ports.

We are confident we can remain the dominant mode for coal transport. For one thing, we know how to do it well. Railroad rates for moving coal are literally a bargain and, over the years, those rates have been going down steadily as a percentage of final coal prices. We can also expand our capacity faster than new mines can come onstream and, in fact, right now our capacity to transport coal substantially exceeds the nation's coal output.

A third bright opportunity for America's railroads is presented by the mergers that have restructured the nation's rail system in only a few years. The CSX combination, which is less than two yeads old, created a system with 27,000 miles of track serving twenty-two states and the province of Ontario.

The biggest boost to us from the merger — and it's a boost for our shippers, too — is the ability it gave us to offer single-system service over practically the eastern half of the nation — from the Atlantic to the Mississippi, from the Gulf of Mexico to beyond the Great Lakes into Canada. We benefit from the use of our new long-haul routes that give us greater operating efficiency and profitability. And the shipper benefits, too, because he need come to only one source to meet his transport needs and very often achieve substantial economies, as well.

As for the railroad mergers set to take place — we say, "welcome to the club." We have expected them, we're prepared to compete with them, and we believe that we'll be able to protect our share of the market.

Having addressed some of the broad challenges-opportunities of the industry, I would be remiss if I did not leave with you, the railroad mechanical and operating officers, as well as the supply industry, some of the challenges and opportunities I see as your contribution to the industry. The motivation driving these opportunities is improved productivity through maintainability and reliability. A lot has been written lately about poor productivity in American business and we in the railroad industry must certainly share our portion of this responsibility.

Certainly, the birth of the diesel locomotive was a tremendous step forward from the steam locomotive. But, gentlemen, that was approximately thirty-five years ago and I don't think the improvements to date have kept pace with the technological advances evidenced in other industries throughout the world. The supply industry has got to take advantage of improved technologies and furnish locomotives, cars and components that will afford greater reliability and utilization of equipment. Some of the things I can think of, for example, are:

Improved wheel life; improved truck steering and damping to reduce wear and damage to equipment and rail; improved diesel engine starting systems to provide dependability under any weather conditions; water-tight cooling systems to allow the use of anti-freeze and provide shut-down / start-up capabilities throughout the year. Lacking this ability will cost Chessie approximately $4.5 million this winter in fuel; why haven't we adapted the solid state contactors of the space age to high power circuits of the locomotive?; the dynamic brake has had a major impact on fuel reduction but why is it such a difficult component to maintain?; better draft gear cushioning to improve train handling and reduce equipment and lading damage; lighter car construction with improved structural qualities; improved adhesion characteristics of locomotives; more fuel efficient locomotives, and improved design of equipment to reduce maintenance costs.

Don't think I am painting a totally negative picture of the progress the supply industry has made. I am only trying to point out that increased research and development is essential if we as users are going to have a more reliable product.

To the railroad people I must ask, have you done everything possible to improve plant and machinery capability? Is our lack of effort in these areas creating loss of productivity? Planning, scheduling, job standards and efficiency measurement systems are areas that you should be addressing to improve shop floor control. I am certain many man-hours are lost because proper materials are not at the required location when needed. Computerization control in these areas can lead to early detection of problem situations which can more readily be handled for correction.

Improved quality of product is something we should all be reviewing constantly. This can take the form of material quality or the quality which an individual builds into the manufacture of a component. Philip Crosby, a noted authority in the field of quality management, has stated in his book, "Quality Is Free," that nearly one-third of everything built in the United States today requires reworking.

In summary, there are many opportunities available to improve our productivity substantially. We must strive to be long-range thinkers as well as short-range doers. We must all work together to achieve a super transportation system in today's competitive world. Other nations may pass us in some industrial and technological adaptations, but never, I hope, in rail transportation.

In conclusion, I believe that railroads do have an unlimited future. I view that future with the same confidence as those people who organized the Baltimore and Ohio way back in 1828. When they were building the first miles of track in Baltimore, they had to cross a stream and ravine, so they built a stone viaduct. They must have had a pretty good idea that railroading was here to stay, because that stone viaduct, first used by horse-drawn coach trains, is still being crossed daily 154 years later by Chessie's biggest and longest freight trains. It gives every appearance of lasting at least another century and a half. I'd call that pretty unlimited, would you?

MR. KAST: Thank you, Mr. Collinson, for your very receptive remarks. They will certainly enhance our vision along in the future as well as the meetings we will be carrying on during the next three days.

It is my pleasure to invite you to enter as many of our meetings as you can, realizing of course that you have a busy schedule. We would be delighted if you will remain with us for an extended time. Also, I would like to present this token to you of our appreciation for your address here this morning. On behalf of the four Associations may we present you with this plaque as a memento of this occasion. [Applause]

Gentlemen, we will now prepare to assemble in our individual rooms for our meetings. Let us now disperse.

[Recess.]

[Mr. N. A. Buskey, President of the LMOA, assumed the Chair.]

PRESIDENT BUSKEY: Good morning, ladies and gentlemen. I apologize for the delay. I am sure you understand we have some substitutions to make, and it takes a little time.

It is certainly a pleasure and is very gratifying to see this fine representation here this morning under somewhat extenuating circumstances. My name is Nelson Buskey. I am President of the LMOA, and I extend my personal welcome to each and every one of you. I sincerly hope that your attendance at these meetings will be a rewarding and worthwhile experience for you and your railroad.

North American railroads are regulated by governing bodies represented here today, and I certainly appreciate their presence. At

MONDAY MORNING SESSION
September 20, 1982

REPORT OF THE COMMITTEE ON SHOP EQUIPMENT

PAUL HOERATH, Acting Chairman
Superintendent Plant Engineering
Consolidated Rail Corporation
Altoona, PA

B. A. CUMBEA
6th VICE PRESIDENT
Manager Loco. Maint.-Engineering
Chessie System
Huntington, WV

this time I would like to ask the representatives of the Federal Railway Administration to please stand and be recognized. Will the representative of the Canadian Board of Transport please stand and be recognized. Are there any representatives here from Mexico or other foreign countries? We have two representatives from the Danish State Railways here. Welcome, gentlemen. We have another gentleman from London, England. Welcome, gentlemen. [Applause]

Ladies and gentlemen, the 44th Annual Meeting of the LMOA is now officially in session.

At this time I would like to introduce Mr. Bud Cumbea, who will be the officer of the session.

MR. B. A. CUMBEA [Manager Locomotive Maintenance-Engineering, Chessie System, Huntington, West Virginia]: Thank you, Nelson. I certainly share with you the thought of recognizing the group who are here as being much larger than we had anticipated when we got up this morning. We are very pleased to see this large turnout.

Recognizing the need for making changes in schedules has created a few problems, I can envision that it may require much greater audience participation and discussion of the papers as they are presented in the next few days. We hope you will help us out in getting over this very undesirable situation that we are faced with.

The Shop Equipment Commmittee this morning will be chaired by Mr. Paul Hoerath, of Conrail. Unfortunately I didn't have time to get together with Paul to develop his biography, so without further ado I will turn the meeting over to Paul.

[Mr. Paul Hoerath, Superintendent, Plant Engineering, Conrail, Altoona, Pennsylvania, read the Introduction in his paper. The paper was summarized as follows:

[Part I, by Mr. G. B. Sweeney, General Foreman, Southern Railway Company, Atlanta, Georgia.

[Part II, by Mr. J. J. Wheelihan, Supervisor - Product Installation, EMD, LaGrange, Illinois.

[Part III, by Mr. Sweeney.

[Part IV, by Mr. K. O. Anderson, Manager Customer Support, General Electric Company, Erie, Pennsylvania.

[Parts V, VI and VII, by Mr. Hoerath.]

MR. HOERATH: This concludes the paper by the reduced number of shop people here today. We probably will be able to answer at least some of your questions. Are there any questions from the floor? If there are no questions, thank you very much for letting us present our paper. [Applause]

PRESIDENT BUSKEY: Gentlemen, before we call on Mr. Axelson to summarize this paper, I have a very pleasant task to perform, and that is to honor a man who is a true innovator and inventor. He was born some 74 years ago in Mississippi, and after 48 years of railroad service he retired in 1971 to open his own business. He has been a member of the LMOA for over 30 years. It is my understanding that he and his wife built the first stack adjustor under their carport. With those clues, I am sure most of you can guess who this gentleman is.

Will Mr. Roy Touchstone come forward, please? Roy, it is with a great deal of pleasure that I present to you this symbol of our LMOA and a lifetime membership for your contributions to the LMOA and the railroad industry.

MR. ROY TOUCHSTONE: This is quite a surprise. As Nelson said, I have been attending the LMOA for many years. I was with the GMO Railroad for 44 years. We started in business making parts for locomotives in 1968, and have been in business for about 14 years.

I appreciate everything that has been done for me, and all the friends I have made in the LMOA, and all my railroad friends and supply friends. We have an advantage over some of them. We have a lot of railroad friends from back in the railroad days, and we have made a lot of friends in the supply business. Thank you.

[The audience arose and applauded.]

MR. CUMBEA: At this time I would like to ask Swede Axelson to summarize the Shop Equipment paper.

MR. KJELL AXELSON [Superintendent Motive Power, Burlington Northern, Inc., St. Paul, Minnesota]: Thank you, Bud. I want to digress for just a moment and relate some first-hand experience I had this morning on the effects of the railroad strike.

Combined with coming to Chicago for the LMOA meeting, my wife and I have had the pleasure of visiting with our son and grandchildren at Naperville, Illinois, 25 miles west of here. Like a good railroader, I had planned this morning on catching an early commuter train and come zipping right into Chicago, but that didn't happen because of the railroad strike, so my alternative was to crank up the car and drive in. What should have been a 45-minute trip at the most turned out to be a 3½ hour trip on our modern expressway system.

Ruth and Roy Touchstone caught by the camera just after Roy was recognized for his outstanding contribution to the railroad industry and to LMOA.

I relate this incident because it sort of points out in a small way to the general public, and my first-hand experience as a consumer, the importance of railroads to our way of life. Realizing this is a small segment, the commuter train service, I think if you multiply that effect by nation-wide or inter-continental railroad systems you will realize that railroads are an important part of our life even today.

Now I would like to get back to the business at hand. In the keynote address this morning, Mr. Collinson very ably stressed the need for increased productivity and quality control improvement. He acknowledged that in many cases the railroad industry still uses outmoded procedures in tooling that are not cost-effective for meeting today's cost control goals. This Shop Equipment Committee is a fine example of ways to meet the ever-present challenge thrown at mechanical departments to do more with fewer labor dollars.

Again, to call attention to Mr. Collinson's remarks, don't just do more — do it better, for improved

KJELL AXELSON
Retired Superintendent Motive Power
Burlington Northern, Inc.
St. Paul, MN

equipment utilization and reliability. That is the task of the mechanical department.

This Shop Equipment Committee has given you some insight into ways to help meet this constant challenge of changing repair requirements for today's modern locomotives, as well as keeping pace with the upgrading of outmoded power so we can maximize that investment. The LMOA Shop Equipment Committee is a hard-working group, and they do expend much effort to keep the industry aware and abreast of the availability of the many ways to improve your locomotive repair and maintenance goals.

If you will just take a few minutes at your leisure to read the detailed report in your LMOA Proceedings book, I am sure it will emphasize the value of their dedication to improvement for the railroad industry and for the locomotive builders and locomotive suppliers. As the old saying goes, even a dog likes a pat on the head; so I am sure you will agree with me that this fine Committee deserves not only a pat on the head but a big, juicy bone to go with it.

I want to thank the Committee for an excellent and thought-provoking technical paper this morning, given under one of the most adverse conditions we have experienced in the LMOA for many years.

Thank you. [Applause]

MR. CUMBEA: Thank you very much, Swede. I certainly would like to echo your remarks about the outstanding job the Committee did today. I think it is very appropriate, in view of Mr. Collinson's remarks this morning, that we did wind up with this change in the schedule, and we had this paper dealing with automated equipment, robots, and so on, directed toward improved productivity and improved quality.

Now I will turn the meeting back to the President for announcements.

PRESIDENT BUSKEY: I, too, think the Committee did an excellent job. Let's give them a rising vote of thanks, after which we will recess until 2 p.m.

[The audience arose and applauded.]

[The meeting recessed at 11:50 a.m.]

MONDAY AFTERNOON SESSION
September 20, 1982

The meeting reconvened at 2:05 p.m., Mr. Nelson Buskey, President, presiding.

PRESIDENT BUSKEY: Gentlemen, at the outset of my presidency of this Association last September 29, I set forth with two main objectives. Number one: Membership. Why membership? Very simple. Membership is truly the strength of our Association. I am afraid that some members and many non-members who should be members might think that we are just thinking of the dues, or the income that comes with new members. Let me tell you, gentlemen, this is not true. While it is true we have one salaried officer, our highly competent Secretary-Treasurer, we do have a payroll to meet. More importantly, new members bring enthusiasm, new problems, new ideas, and new solutions.

I am very proud to announce to you that we surpassed the 1981 membership sometime in August, the first increase in membership since 1976 and under the most trying conditions, with the country, and the railroads in general, in the most depressed condition since the late 1930s. The General Membership chairman will give you a complete update later this afternoon.

The second challenge or objective presented to you was to encourage your young officers to participate and become active members of our technical committees. Again, you have met that challenge. My hearty congratulations and personal thanks to the vice presidents, assistant vice presidents, and chief mechanical officers of this nation's railroads for their very fine selection of young, eager and ambitious officers for these committees.

I wish to give the credit for the success of this meeting to the men who rightly are entitled to it — the technical committee chairmen. These men, along with their committees, are the backbone of the Locomotive Maintenance Officers Association.

It is no accident that the technical papers are so concise and accurate. As this meeting adjourns, and even while it is in progress, the technical committee chairmen are meeting with their committees to develop next year's program.

After the meeting adjourns, the chairmen send out questionnaires and outlines to gather in the most advanced technical knowledge they can acquire for the papers in the ensuing year. These men gather the information, consolidate it, and assemble it for the beginning of their advance preconvention report. This is done on the time they can work in with their regular positions. It is through the ingenuity of these men that this information is assembled and made ready for the meetings at the various rail-

N. A. BUSKEY
PRESIDENT
Asst. Gen. Manager-Locomotive
Chessie System
Huntington, W. Va. 25704

road clubs over the nation where our trial runs are made.

I wish to express my appreciation to the officers and members of the Chicago Railroad Diesel Club, the Southern and Southwestern Railway Association, the Southwestern Railway Club, officers of the Union Pacific Railroad, Omaha, Nebraska, the Santa Fe Railroad, Kansas City, Kansas, and the Consolidated Rail Corporation, Altoona and Philadelphia, Pennsylvania for hosting our six preconvention reports this past year.

We welcome the help of the manufacturers and other supply people who freely give of their time and knowledge to assist us in our program.

I have read the reports this year by all the committee chairmen, and wish to congratulate each and every one of them on their efforts and on a job well done. I think their papers are thought-provoking and will bring out a lot of good facts.

You gentlemen all are part of this Association, and the success of the papers and the meeting depends on your participation. We earnestly hope that you will enter into discussion of the papers presented. Feel free at any time to ask questions on the section of the report being given, or offer your solution to the problem being discussed. We all have problems and questions to be asked, and we are all looking for reasonable answers.

Efficient and progressive managements of our railroads are one of the reasons we can continue to be a competitive mode of transportation in a race that has all the cards stacked against us. We are neither subsidized nor protected, nor do we get our roadways constructed and handed to us with the Corps of Engineers maintaining them; nor do we get our depots and facilities built by tax dollars and presented to us; nor do we get the tremendous tax bite that is given toward the building of highways and their continual maintenance. Even our tax dollars are taken with no thought of giving relief, and these tax dollars are used in the maintenance of highways and ports for both water and air.

Our managements are alert and receptive to improvements such as improved motive power, maintenance practices, computerization, modernization of maintenance facilities, and improved tooling with the most availability of locomotives

by cutting down on maintenance time in shops and layover time at end of runs where maintenance forces are not available.

We know your management is progressive, by your attendance here at the Annual Meeting in Chicago. In this way you can pick up the best of the reports and can take them home to improve your own maintenance practices, or question the facts in the paper to prove them.

Since you have a management that is interested in improvements, as your attendance here proves, show them that you are definitely a part of their team for economy and efficiency and availability so that, mechanically speaking, you are getting the most from your maintenance dollar that can be achieved.

On behalf of all of us in the LMOA, I would like to express our most sincere appreciation to the supply people who have supported our organization by their advertising and associate memberships. I have always felt that your advertising dollar goes farther with us, and your message is certain to be in front of the people who really count for you, our entire membership, including chief mechanical officers, general managers, purchasing officers, and presidents of our railroads.

It is a real joy to me to read the names of our Advertisers Honor Roll. If by chance your company's name is missing, won't you please exert a little extra effort to have it added before the end of this year? Let me assure you that without the fine support of the supply people we would be unable to carry on as we have in the past, and plan for the future.

The success of this organization has been made possible through the years by the efforts of many capable and hard-working men. The active membership is an inspiration to the committees and officers.

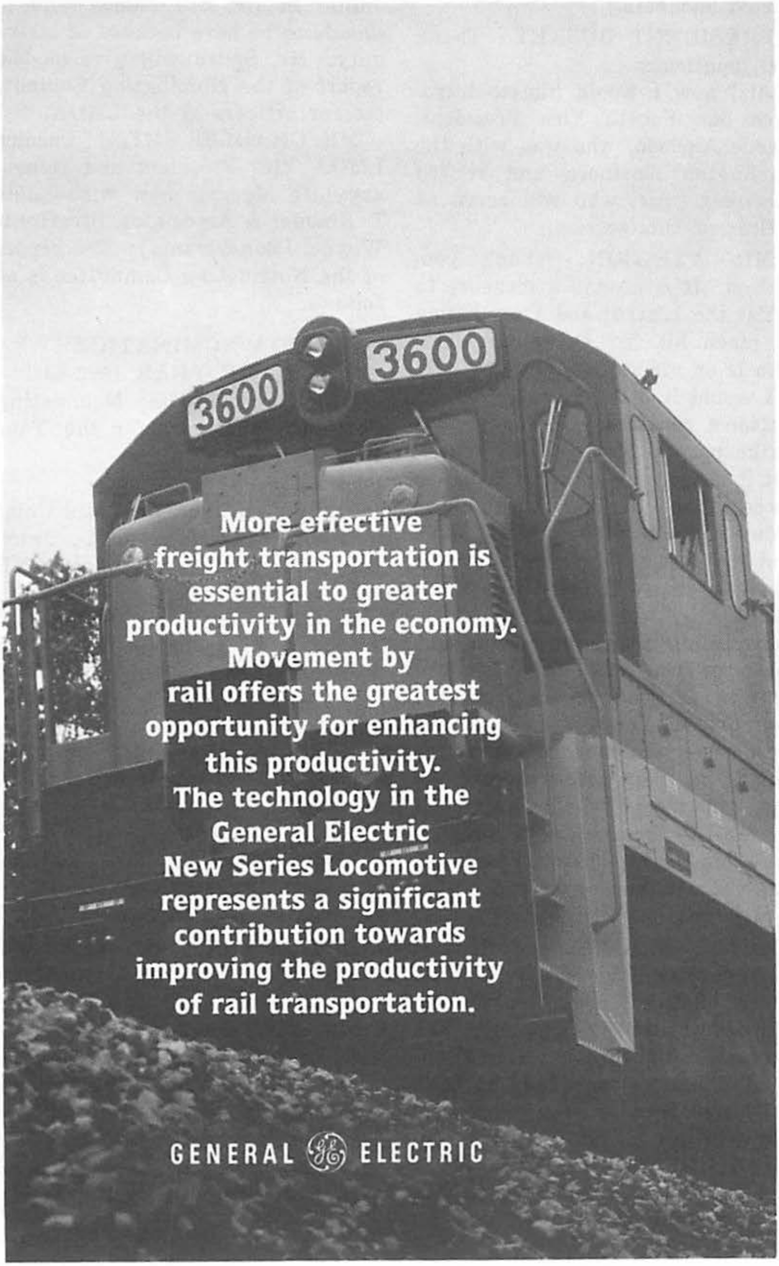
I am going to forego the individual introduction of the officers of the Association at this time, since they are listed on pages 118-132 of the Preconvention Report. Each one has a part in our program and will at some time during the program be speaking to you from this rostrum. You will also note that the personal history of the committee chairman prefaces each committee report.

The support and work of these officers makes it possible to bring these meetings to you, and ensures the quality and value of them to you. The work they have done is significant and valuable, and deserves your appreciation at any opportunity you may have to express it to them. I want to extend to each and every one of them my sincere appreciation for the support they have given me this year.

Thank you. [Applause]

At this time will you please stand for a moment in tribute to honor those LMOA members who have died during the past year, particularly Mr. James W. Gestner, our keynote speaker in 1980.

[Silent standing tribute to de-


3600
3600
More effective freight transportation is essential to greater productivity in the economy. Movement by rail offers the greatest opportunity for enhancing this productivity. The technology in the General Electric New Series Locomotive represents a significant contribution towards improving the productivity of rail transportation.
GENERAL ELECTRIC

parted members.]

PRESIDENT BUSKEY: Thank you, gentlemen.

And now I would like to introduce our Fourth Vice President, Swede Axelson, who was with the Burlington Northern and retired this past year, who will serve as officer of this session.

MR. AXELSON: Thank you, Nelson. It is always a pleasure to assist the LMOA, and I am happy to pinch hit for Darrell Walker, who is on strike duty.

I would like to enlarge a bit on Nelson's remarks. Of course this strike proposition is pretty rough, but it is certainly gratifying to see those of you here in the audience today to help support the LMOA and make it a worthwhile session so that you will have averted a disaster by not having to cancel the meeting altogether. I am sure those of you who are here will hear some good papers from the committees. You will have to bear with us on skeletonized committee reports as they are presented.

At this time I would like to call on Mr. Ky Pruchnicki to give us the Membership Report, and enlarge on Mr. Buskey's comments.

MR. KY PRUCHNICKI [Past President of LMOA and General Supervisor Locomotive Maintenance (Retired), Southern Pacific Transportation Company, San Francisco, California]: Our membership figures show that we have 1,728 members or 86.4 percent of our goal set in 1981. Thank you.

PRESIDENT BUSKEY: Now I will call on Charlie Smith who is filling in for Bill James who is unable to be here because of strike duty. Mr. Smith will give us the report of the Nominating Committee for officers of the LMOA.

MR. CHARLES SMITH [Former LMOA Vice President and Honorary Life Member now with Louis T. Klauder & Associates, Strafford-Wayne, Pennsylvania]: The report of the Nominating Committee is as follows:

LMOA NOMINATIONS FOR THE YEAR 1982-83

Following is the Nominating Committee's Report for the Year 1982-83:

President:
Frank D. Bruner, Assistant Chief Mechanical Officer, R&D, Union Pacific Railroad, Omaha, NE

1st Vice President:
R. R. Holmes, Director Chemical Labs & Environment, Union Pacific Railroad, Omaha, NE

2nd Vice President:
D. M. Walker, Diesel Superintendent, Southern Railway Co., Atlanta, GA

3rd Vice President:
W. R. James, Chief Mechanical Officer-Locomotive, Chessie System, Huntington, WV

4th Vice President:
D. H. Propp, Chief Mechanical Officer, Burlington Northern Inc., Billings, MT

5th Vice President:
B. A. Cumbea, Manager Locomotive Maintenance - Engineering, Chessie System, Huntington, WV

6th Vice President:
M. Gogol, Chief Quality Control Officer, Southern Pacific Trans-

portation Co., San Francisco, CA

Executive Committee:

E. R. Hafling, Engineering Assistant, Atchison, Topeka & Santa Fe Railway, Topeka, KS

J. D. Smalling, Chemical Engineer-Mechanical Dept., Southern Pacific Transportation Co., San Francisco, CA

D. L. Ward, Assistant General Locomotive Foreman, Burlington Northern, Springfield, MO

J. L. Kuhns, Manager Planning & Maintenance, The Family Lines Rail System, Jacksonville, FL

D. G. Goehring, Manager, Maintenance Planning, National Railroad Passenger Corp., Washington, DC

T. L. Westerfield, Senior Electrical Engineer, Chicago & North Western Transportation Co., Chicago, IL.

MR. SMITH: This is the proposed slate. Are there any nominations from the floor? If not, all those in favor of electing the slate please signify by saying "aye"; those opposed, "no". The slate is elected unanimously.

MR. AXELSON: Thank you, Charlie.

As you will note, there is a lot of heavy talent coming up, but when the officers serve their terms through the LMOA they don't just fade away. Their talents are catalogued.

We are going to call on another switch-hitter, Past President Larry Booth, who was a heavy hitter in his time and still is. We will ask him to give the financial report at this time. Is Larry here? Evidently he couldn't make it. Joe, we will call on you to give the report.

[Secretary Joseph J. T. Koerner read the financial report.

MR. AXELSON: Thank you, Joe. Joe did such a good job that we will keep him up here so he can give us the report of the Secretary.

SECRETARY KOERNER: We have good news and bad news.

As mentioned by President Buskey, we have exceeded last year's membership total, and had it not been for the strike greatly curtailing attendance here, I believe we would have reached our goal of 2,000 members before adjournment.

On the other hand, financially we are falling short of the break-even point, and so will have to increase membership dues for the coming year. Advertising rates will also be increased.

On the bad news side, we lost the services of our very able assistant at the LMOA office in Huntington. Some of you may have had the pleasure of having met Sue Evans in Huntington at the Southern & Southwestern pre-convention presentations. For those of you who don't know her, Sue is a very capable and conscientious person, and was of real value to LMOA. She will be missed. We wish she could be here in person to accept our thanks. However, on behalf of myself and the LMOA I wish to extend our thanks to Sue and to wish her well in the future.

LOCOMOTIVE MAINTENANCE OFFICERS ASSOCIATION
FINANCIAL REPORT
FOR THE YEAR ENDED DECEMBER 31, 1981

OPENING BALANCE JANUARY 1, 1981:			
In Checking Account, Security Bank		$ 2,929	
In Reserve Account, Security Bank		17,360	$20,289
RECEIPTS:			
Dues — Active Members	$ 9,610		
Dues — Associate & Foreign Members	8,274		
Registration Fees	1,880		
Advertising Revenue	23,938		
Refund of Income Tax & Penalties for the years 1973, 1974 & 1975	3,106		
Interest received from the IRS on above refunded amounts	1,065		
Interest from Security Bank on Reserve Account	759		
Miscellaneous	501		
TOTAL RECEIPTS		$49,133	
EXPENDITURES:			
Convention, Publication and Travel Expense	$24,827		
Office Expense, Office Assistance, Supplies, Postage, Stationery and Payroll Taxes	22,364		
TOTAL EXPENDITURES		47,191	
EXCESS OF RECEIPTS OVER EXPENDITURES			1,942
CLOSING BALANCE DECEMBER 31, 1981			$22,231
In Checking Account, Security Bank		$ 4,112	
In Reserve Account, Security Bank		18,119	
Balance as Above		$22,231	

APPROVED:
N. A. Buskey — President

APPROVED:
F. D. Bruner — 1st Vice President

Approved this 6th day of April 1982, Chicago, Illinois

MONDAY AFTERNOON SESSION
September 20, 1982

REPORT OF THE COMMITTEE ON NEW DEVELOPMENTS

D. G. GOEHRING, Chairman
Mgr. Maintenance Planning
National Railroad Passenger Corp.
Washington, DC

KJELL AXELSON
Retired Supt. Motive Power
Burlington Northern, Inc.
St. Paul, MN

MR. AXELSON: Thank you very much, Joe. In spite of the adverse effects of the strike, at least we have some upbeat news in the form of high-caliber officers coming up. The membership figure sounds good, and we are holding our own on finances. I think there is a lot to be said for that in the handling of the LMOA.

We are going to give another upbeat note right now, and I will call on Mr. David Goehring and his Committee on New Developments to come forward, please.

MR. D. G. GOEHRING [Manager, Maintenance Planning, National Railroad Passenger Corporation, Washington, D. C.]: Before I begin, I would like to tell you that we had a very successful presentation at Omaha. The people from the Union Pacific aren't here to hear this, but Frank Bruner will be our next President. He did an outstanding job, and our Committee wants to thank Frank and his people and also Mr. McDonough and his staff for the support they gave the LMOA at that presentation in Omaha.

[The paper was summarized by Mr. Goehring, Mr. Whittle and Mr. Chirikos.]

MR. GOEHRING: That completes the paper. We will be glad

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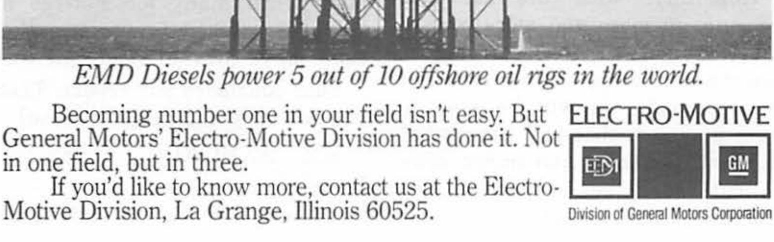
EMD Diesels power 6 out of 10 workboats in our size range in the nation.



EMD Diesels power 5 out of 10 offshore oil rigs in the world.

Becoming number one in your field isn't easy. But General Motors' Electro-Motive Division has done it. Not in one field, but in three.

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ELECTRO-MOTIVE

Division of General Motors Corporation

to entertain any questions or comments.

MR. DICK GODDARD [Touchstone Railway Supply & Manufacturing Company, Inc., Jackson, Tennessee]: On the GP49 locomotives, do they have a soldered radiator or mechanical bond radiator?

MR. D. W. CHIRIKOS [Manager Technical Section, EMD, LaGrange, Illinois]: I believe the basic radiator is the soldered radiator. The other would be an EDL. That is the basic configuration as I know it.

I would like to add something, Dave. Your last item is of particular interest to me because I used to be in our Service Department, Statistical Group, which keeps track, through warranty records, of failures of components out in the field, and so on. It would be of interest down the road if the railroads and the builders could eventually get a system that is compatible and would show what happens to components after they are out of the warranty period. We can only track during the warranty period, and we use that as our major guide on how our components and systems are doing.

Hopefully, with the railroads gearing up more and more toward these computer data base systems, somehow between the builders and the railroads we will be able to have a system that will show what happens to major and minor components once they are out of the warranty time period.

MR. CUMBEA: I have a brief answer to that particular question. Chessie is in the process of converting their old diesel data system to a new program which we call our Locomotive Maintenance Information System. With this we will be following failure trend and analysis by various components over the life of a locomotive. Anything we have available in our system we will be happy to make available to the locomotive builders in helping them assess their problems.

MR. GOEHRING: In the past the New Developments Committee has stressed the reporting of locomotive and component performance because, as we know, the locomotive's reliability depends on every component functioning properly. It is analogous to the story of because a nail was missing the shoe was lost, and so on.

A very minor component failure can throw a locomotive out of service. To help combat this, the computer is going to be used by more and more railroads to track the service life of locomotive components. I think this tracking of component service life is going to become absolutely necessary to enable railroads to operate particularly when many locomotives are being dispatched for several thousand miles over merged rail lines.

That concludes our report. Thank you all very much. [Applause]

MR. AXELSON: Thank you, Dave.

I would now like to call on Bud

Cumbea to summarize the Commitee's report.

MR. CUMBEA: Thank you, Swede. I can think of nothing more important today than the need to totally evaluate fuel savings potential. Fuel is the single most costly material item to a railroad today. Thus, cold weather engine shutdown protection becomes more and more important. However, each potential device must be evaluated from a cost-benefit standpoint to determine not only the ROI which may be achieved but the potential adverse effects it might have on the locomotive, particularly the diesel engine.

We are happy that this Committee addressed the problem and offered some new thoughts on winter shutdown protective methods and devices. We are also happy to see the comments of the Committee on the Farr four-stack manifold and the verification of the potential fuel savings.

The new GE fuel system was long overdue, and it is hoped that this will provide the solution to a long-existing problem. This continuing need for measuring work performed as a supplemental tool for determining maintenance schedules and policy was addressed by the Committee. Where there seems to be progress in this area, further development in instrumentation and reliability of measurement equipment is needed.

It is always a pleasure to hear from the builders concerning their latest locomotive design changes. Where we all know the present

B. A. CUMBEA
6th Vice President
Manager Loco. Maint.-Engineering
Chessie System
Huntington, WV

market for new power is seriously depressed, we welcome the features presented on the new GE B-30-7A and EMD GP49. Potential electrification is by no means a dead issue, so the comments offered by the Committee are most timely and appropriate.

The use of computers as a management tool is growing by leaps and bounds. The development of hardware and software is progressing at such a rapid pace that programs which look good today may be obsolete tomorrow. This area alone offers the Committee a challenge for many years to come in attempting to keep us updated on new developments.

The title of the paper today was related to Quality, as I think all papers in this year's program are related to Quality. Mr. Collinson, in his keynote address this morning, quoted from a book entitled Quality Is Free, and in this same book the definition of quality is "conformance to specification." Where we have had some very adverse and trying conditions to live with today, I think both committees that have reported have conformed very well to specifications.

Thank you very much. [Applause]

MR. AXELSON: Thank you, Bud. We have the bases loaded, and we will call on the heaviest hitter we have to wrap up the game. Nelson, if you will.

PRESIDENT BUSKEY: My schedule says I should make some announcements, but I have none.

SECRETARY KOERNER: Perhaps the Secretary failed to furnish you with the President's announcements. Primarily they include telling the people who took part that when Charlotte sends them the transcript they should correct it and return it to her as soon as possible, which is important. Of course the Wednesday meeting you can announce later.

PRESIDENT BUSKEY: Thank you, Joe.

I too echo Bud Cumbea's remarks concerning this Committee. They did a fine job, and they deserve a rising vote of thanks.

[The audience arose and applauded.]

[The meeting recessed at 3:45 p. m.]

TUESDAY MORNING SESSION
September 21, 1982

REPORT OF THE COMMITTEE ON DIESEL ELECTRICAL MAINTENANCE

PICTURE
NOT AVAILABLE

T. L. WESTERFIELD, Chairman
Senior Electrical Engineer
Chicago & North Western Transp. Co.
Chicago, IL 60606

R. R. HOLMES
1st VICE PRESIDENT
Dir. Chem. Labs & Env.
Union Pacific Railroad
Omaha, NB 68179

The meeting reconvened at 9 a.m., Mr. Nelson A. Buskey, President, presiding.

PRESIDENT BUSKEY: Good morning, gentlemen. It is a real pleasure to see so many here this morning. I would like to introduce our First Vice President, Dick Holmes, from the Union Pacific Railroad, who will act as officer of the session.

MR. R. R. HOLMES [Director Chemical Labs and Environment, Union Pacific Railroad, Omaha, Nebraska]: Thank you, Nelson. It is a real pleasure to be here with this group this morning. Sometimes smallness means greater efficiency, so we will hope that is the case this morning.

It is my pleasure to introduce the Diesel Electrical Maintenance Committee, and Tom Westerfield, the chairman.

[Mr. Holmes introduced Mr. T. L. Westerfield, Senior Electrical Engineer, Chicago & North Western Transportation Company, Chicago, Illinois. Mr. Westerfield then introduced the members of his Committee.]

[Mr. Westerfield summarized the report.]

MR. WESTERFIELD: I will now invite questions from the floor on any of the topics we have talked about. I guess all the agitators must be absent today. We must be performing very efficiently today, because we have managed to completely snow the audience this early in the morning.

If there are no questions, I will turn the meeting back to our presiding officer.

MR. HOLMES: We have plenty of time. If there are no questions or comments, I would like to ask Mr. Frank Bruner to summarize the paper please.

MR. FRANK D. BRUNER [Assistant C. M. O.-R & D, Union Pacific Railroad, Omaha, Nebraska]: Thank you, Tom, and your Committee. I don't blame the audience for not asking questions about all this material.

Tom, your paper was very well given, particularly for the railroad people. Unfortunately a lot of railroad people can't be here. However, if they have their books and read the presentations, they will get some very good tips.

I did like a couple of things you stressed. One was about doing it right. Too many times in railroading we don't take the time to do it right, but we always seem to take the time to do it over again.

Particular care in the checking out of locomotives and transition is very important. I well remember a personal experience of putting an Alco locomotive almost through the roundhouse wall. That was very embarrassing, even though the brakes were set. Some of those old systems could get locked in through grounds, and this could cause serious trouble.

The old adage, "I saw the smoke coming out, so I immediately took off my jumper," has happened before, too.

I think your paper was very well put together, and I want to thank the Committee for their work on it. Let's give the Committee a big hand. [Applause]

TUESDAY MORNING SESSION
September 21, 1982

REPORT OF THE COMMITTEE ON DIESEL MECHANICAL MAINTENANCE

PICTURE
NOT AVAILABLE

L. M. DANIEL, Acting Chairman
Sr. Mech. Asst.-Motive Power
Canadian National
Montreal, Quebec

B. A. CUMBEA
5th VICE PRESIDENT
Mgr. Locomotive Maint.-Engr.
Chessie System
Huntington, WV 25704

PRESIDENT BUSKEY: Gentlemen, at this time I would like to introduce our Fifth Vice President, Bud Cumbea, from the Chessie System.

MR. CUMBEA: Before I introduce the chairman of the Diesel Mechanical Maintenance Committee, I would like to express my personal appreciation to the former officers of the LMOA and the committee members who have been so willing to cooperate in trying to carry on our program.

We have a substitute in place of our good friend Bill Brown, chairman of the Diesel Mechanical Maintenance Committee, who could not be here. I would like to introduce Len Daniel.

[Mr. Cumbea introduced Mr. L. M. Daniel, Senior Mechanical Assistant - Motive Power, Canadian National, Montreal, Quebec. Mr. Daniel then introduced Mr. C. M. Dathan, Bombardier, Montreal; Mr. A. C. Hillhouse, General Electric Company, Erie, Pennsylvania; and Mr. D. W. Chirikos, Manager Technical Section, EMD, LaGrange, Illinois.]

[The report was summarized by Mr. Dathan, Mr. Hillhouse and Mr. Chirikos.]

MR. DANIEL: I regret the absence of Bill Brown, our esteemed chairman, and the other members of the Committee who are absent, but now is your opportunity to ask any questions of the three distinguished representatives of the builders. Are there any questions to be directed to these three gentlemen?

MR. G. L. KARNER [Staff Engineer, Gulf Research & Development Company, Pittsburgh, Pennsylvania]: Maybe I misinterpreted what you said, but I believe the statement was made that 40 to 50 percent of unit time is at idle. Then the remark was made that 40 percent of the total fuel burns at idle. That would seem very high.

MR. CHIRIKOS: That was supposed to be in time only.

MR. DANIEL: If there are no further questions, I will turn the meeting back to Mr. Cumbea.

MR. CUMBEA: I will call upon another pinch-hitter to summarize the paper. Charlie Smith, will you come up, please.

MR. SMITH: Thank you, Bob.

The theme of the Diesel Mechanical Maintenance Committee was Fuel Conservation. Poor maintenance may cause an increase in fuel consumption, and conversely greater maintenance expense may be required to reduce fuel consumption. The magnitude of the railroad's fuel expense, $5 billion per year, is awesome. Only one percent of that figure is $50 million. It is readily apparent that good maintenance or poor maintenance

CHARLES SMITH
Honorary Life Member
Louis T. Klauder & Associates
Strafford-Wayne, PA

will have a very significant effect on that figure.

The Committee has outlined a number of approaches to fuel conservation, such as engine shutdown and low idle, and has outlined their effect on maintenance. The Committee has provided a four-page tabulation of modifications to locomotives which may be undertaken to save fuel and an assessment of their cost and benefit. These modifications include fuel savers, standby heaters and improved exhaust manifolds.

The Committee has emphasized the importance of tightly controlling the delivery of fuel to locomotives. The gallon of fuel that does not reach the locomotive costs as dearly as the fuel that is improperly burned. The policing of fuel stations is a most important aspect of fuel conservation.

The Committee has treated the maintenance of turbochargers. Turbochargers are a very important component of the modern fuel-efficient diesel engine.

May we have a rising vote of thanks for Messrs Daniel, Dathan, Chirikos and Hillhouse, and for the other Committee members, including chairman Bill Brown, who are unable to be in attendance?

[The audience arose and applauded.]

MR. CUMBEA: Thank you very much, Charlie.

I couldn't help but think, during the reading of this paper, that some of the remarks I made yesterday in summarizing the New Development Committee would be very appropriate for topics in this morning's paper. Fuel savings are a very critical area which concerns us all. We are also concerned with the potential adverse effects that some of the fuel savings features may alter.

PRESIDENT BUSKEY: Gentlemen, I think the Committee did a remarkable job this morning.

This concludes the program for the morning. We will reconvene at 2 p.m.

[The meeting recessed at 10:45 a.m.]

TUESDAY AFTERNOON SESSION
September 21, 1982

The meeting reconvened at 2 p.m., Mr. Nelson Buskey, President, presiding.

PRESIDENT BUSKEY: Gentlemen, welcome to our Tuesday afternoon session.

Several times in the last two days I have been questioned about the new logo on our blazers. Last year we decided to get new blazers, and we charged Mr. Swede Axelson with the responsibility of designing a new logo. I would like Swede to come up and tell us about the work involved in it.

MR. AXELSON: Nelson isn't satisfied with putting me to work — he wants me to explain everything, too. This year you should have received your new LMOA membership card. Maybe from force of habit you didn't even look at your card. If you have it with you, pull it out. Look at the top and you will see a brand new logo representing the LMOA. It is more than just a pretty picture.

The committee, when we discussed this last year before I became inactive, wanted to try to come up with something that was simple and direct and yet said it all. For you younger members, if you will look at your card, to the left there is a strange piece of prime mover equipment called a steam locomotive. For those of us who cut our teeth on them earlier on, it was a way of life, and a hard way of life, and a costly way of life by today's standards. Nevertheless, progress and evolution carried it over to the right side, with a prime mover called a diesel electric locomotive.

You will notice more importantly right in the middle of that transition and evolution is "LMOA," and that is what it is all about — not only brilliant improvement to change motive power, but to try to keep abreast of the innovations that the suppliers and others come up with.

With all that discussion in mind, that is what your new LMOA logo is all about. Thank you.

[Applause]

PRESIDENT BUSKEY: Thank you, Swede.

Again I have a very pleasant task, and that is to say that my tenure as President has now ended. I want to call on Mr. Frank Bruner, your new President. Frank, will you come to the podium so I can present you with the gavel? Congratulations. I hope you have a successful year.

[Mr. Frank D. Bruner assumed the Presidency.]

PRESIDENT BRUNER: Thank you, Nelson. Following Nelson is a tough act to follow in the LMOA. He has been a great leader this past year. Everybody knows times are tough, but I think that is part of the railroad heritage we all go through in our life, to learn how to live tough and keep grinding it out.

When you look at our situation today, I certainly have a feeling of being elected to the presidency of Lebanon. [Laughter] I say that jokingly, because what I really mean is that my railroad support isn't here. But you people out there are the best support we have in the organization, and I appreciate the fact that you are here.

When I look back on my time with the LMOA, it goes back to the early 1960s. I came to Chicago at the invitation and direction of Mr. Dave Newhart. I had the pleasure of attending my first meeting when we were trying to get a lot of things done in the area of simplifying locomotives. We were looking at challenges of running trains 80 miles an hour, changing gear ratios, and we had a lot of problems to solve.

I got on the Electrical Committee (at that time Bob Clevenger was the chairman) and I think we stirred up enough trouble that I decided I had better be his vice chairman. In due time I took over the chairmanship of the Committee, and it was a pleasure working with those people.

I moved up through the regional executive positions. This is one place where you have to keep going and outlive others. It takes a long time to get to the top. We have had a few people retire, and other things have come up, and I would point out the fact that I will be President of the LMOA this year and we will have another Union Pacific gentleman, Dick Holmes, who will immediately follow me. Normally we try to spread it out a little bit. Dick is a good worker. I know, because he works for me. He is a brilliant man, and he is a great contributor to this organization in the sense of lubricating oils and fuels, and such things.

The challenge we will have in the coming year is probably well brought out in what is going on today. Nothing seems to be stable and as we would like to have it, but the ability that we as railroad people and you as suppliers who are dependent upon the railroads — and it goes the other way, too — we are dependent upon you — will be stressed and strained in the coming year, as it has been in the past year or so.

It certainly isn't easy, and there have been tough times. We hope some others come around. Let's keep plugging away, all of us —

F. D. BRUNER
PRESIDENT
Asst. Chief Mechanical Officer-R. & D.
Union Pacific Railroad
Omaha, NB 68179

our railroad people, the organization of the LMOA, and everybody. We have some very fine people in this organization coming up through the ranks who couldn't be here today. They are out running trains or keeping the traffic moving to get through this crisis. I don't propose to stand up here and take sides one way or the other on what is going on today; but no matter how it is, it is embarrassing to all of us, and it is not something we would like to have happen.

The year to come will be tough. I am going to ask my people to get out and contact the suppliers again, and beg for your membership and your support and your advertising. Believe me, you are a big person in this organization. You mean a lot to us, and I hope our work will give you direction and ideas. I hope our recommendations will give you things to work on. Things brought up in the Electrical Committee this morning, on monitoring systems, should be worked on. You are part of it. We will be hoping to hear from you.

We are going to work together as an organization to help better our railroads. The LMOA through the years has been a leader in advancing new schemes of improving motive power, in looking at new fuels and specifications, and working with the oil suppliers and developing a higher standard of oil.

We are coming up to Generation 4 at this time. The LMOA has been influential. The oil companies and the suppliers and manufacturers have all worked well, and most certainly the committees have worked too. We would like to work with all those who want to better the railroads. We like to mix in with the AAR on numerous occasions. In some places we are the leader. In many other places they are the leader, but we still have a common goal.

While I am talking about that, I would like to mention that there will be a joint conference sponsored by the AAR and supported and helped by the LMOA in Memphis, Tennessee on November 30—December 1-2. Put that ony your calendar because that will be a conference of alternative energy, fuels, power, motive power, and the effective and efficient use of the energy and means of moving trains. It is going to be a very fine conference, and we would like to see you all there. We are glad to participate with the AAR in that effort.

You are going to hear from me throughout next year's session. I will be talking with you and begging you to consider the LMOA again with your membership and advertising this coming year. We appreciate your support, and I hope you appreciate our support, too. I will accept the challenge as President of the LMOA. It means a great deal to me, and I am very honored. I appreciate that you have given me the opportunity to be your leader this coming year. Thank you. [Applause]

I would like to ask Past President Ky Pruchnicki to come up, please. We have a job for him.

MR. PRUCHNICKI: The new President has already put me to work. We don't want Nelson to slip away from us. We want him to remember us for a long time for the good job he has done, so we would like to present him a little token and also a life membership. Nelson has done a fine job. He will be chairman of the Board next year. We appreciate everything you have done for us, Nelson. [Applause]

PRESIDENT BRUNER: Thank you, Ky. I know Nelson wouldn't want anybody else to present him with that fine desk set.

I will call upon Swede Axelson for the next presentation.

MR. AXELSON: Just a couple of words about Nelson. From where you sit, you see him as one hell of a good leader, but from where I used to sit I will say he is one hell of a hard taskmaster. I thought after 41 years of being ridden hard and put away wet, and earning the right to retire, which I have recently done, I was immune from being president of LMOA and other LMOA duties, so I could sit back and enjoy things like a lot of people do.

However, in the course of working for Nelson as our President, he was always hanging on Swede. I'll tell you, Nels, I have waited a long time, and it is with great

Past President John W. Hawthorne, left, presents Nelson Buskey the General desk set emblematic of life membership in LMOA upon completion of his tour as president. 5th Vice President Bud Cumbea beams his approval.

Past President Ky Pruchnicki, left, presents the coveted Past President's Pin to Nelson Buskey. Former LMOA Vice President Charles M. Smith looks on.

Past Presidents John Hawthorne and Larry Booth, left of photo, take pleasure in presenting outgoing president Nelson Buskey with a leather bound copy of the record of his year as president of LMOA. Bud Cumbea witnesses the event.

personal pleasure that I am finally going to get a chance to hang one on you. I would like to present to you the LMOA Past President's Pin, which you so richly deserve. God love you. [Applause]

PRESIDENT BRUNER: I would like to call on Charlie Smith to handle another little chore.

MR. SMITH: We have one more thing for Nelson. This is the record of his tenure in office. This is a copy of the 1982 Proceedings of the LMOA. [Applause]

PRESIDENT BRUNER: That concludes this part of the program. Nelson, you have been honored, and deservedly so, and I will call upon you to help me a lot this coming year. Nelson has been a good leader and tough taskmaster.

TUESDAY AFTERNOON SESSION
September 21, 1982

REPORT OF THE COMMITTEE ON FUEL AND LUBRICANTS

R. R. HOLMES, Presiding
1st VICE PRESIDENT
Director Chemical Labs & Env.
Union Pacific Railroad
Omaha, NB 68179

It is now time to call upon the Committee on Fuel and Lubricants. Will they come up, please.

MR. HOLMES: I would like to say that I certainly appreciate the fine remarks Frank made. I thought this was his day, but in view of the fact that the man is my boss, I can't argue too much with what he said. I do appreciate it, anyhow.

We have an excellent panel of experts present, who constitute more than a quorum for this presentation, one of the largest during the entire convention. However, since Mr. Don Hudgens, chairman of this Committee, is unavailable for this session, the second-string quarterback has been substituted, and I guess I am it. I will attempt to substitute for Don. We have all of our people here who are going to present the various parts of the paper.

Also, at this time I would like to express appreciation to Fred Burchett and all the others responsible on the Santa Fe for the opportunity and for hosting the Fuel and Lubricants Committee at the Pre-Convention presentation at Kansas City this year.

[Mr. Holmes introduced the members of the Committee.]

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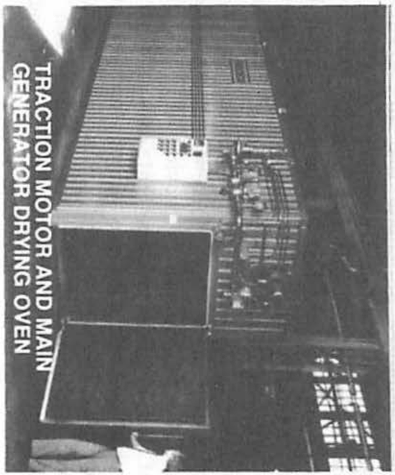
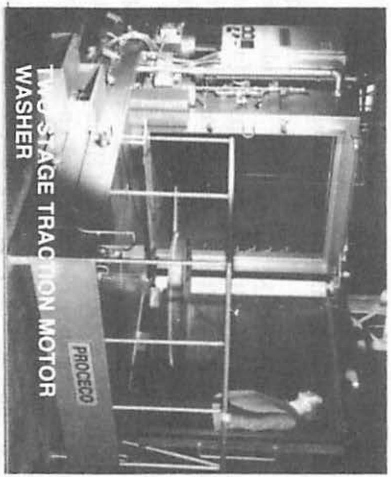
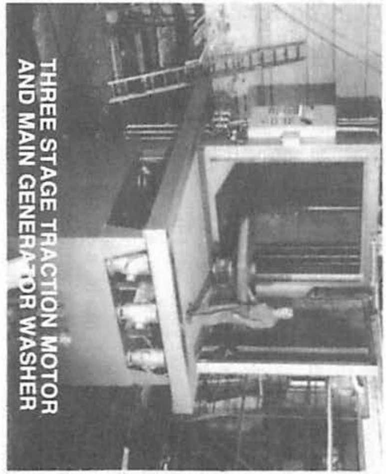






[Mr. J. G. Hoffman, Manager Combustion Engineering, General Electric Company, Erie, Pennsylvania, summarized Part II of the paper.]

MR. HOLMES: If anybody has a question, please identify yourself for the purpose of the record. That includes everyone at the speaker's table, because there are no name cards.

I believe I made a mistake, and want to make a correction. At the beginning I identified the first section to be presented as Energy Conserving Lube Oils, whereas it obviously was the Alternate Fuels Update section. If there are any questions, Jack will entertain them at this time.

MR. HOFFMAN: Hopefully I didn't bore you all to death. With all the talent sitting out there, Jack Hayden and Tom Pratt from EMD ought to at least have a chance to rebut, or whatever.

MR. D. G. GOEHRING [Manager Maintenance Planning, National Railroad Passenger Corporation, Washington, D.C.]: Do you and the Committee anticipate that in time the oil companies will provide blended fuel oils for locomotives, or would the blending be done by the railroads?

MR. HOFFMAN: My personal opinion is that some oil companies presently have the wherewithall and the willingness to provide all of the blended product that railroads in their area are willing to accept. There are, and probably will continue to be, transportation difficulties. For example, some railroads currently obtain their fuel through a pipeline arrangement. Black fuels may not be sent through public pipeline systems; so there is a logistics problem to be overcome.

I would believe that in time some railroads will attempt to do their own blending in their own facilities. I believe they should move cautiously in that endeavor, because blending No. 6 and No. 2 fuel, a very aromatic mess, together to get a stable, filterable material is pretty complex. They at least should seek a lot of assistance from knowledgeable oil companies if they take that approach.

MR. GOEHRING: I have one more question. Is the thrust of oil blending to stretch the amount of fuel oil available to the railroad industry, or is the thrust to reduce the cost of today's fuel oil?

MR. HOFFMAN: The principal drive is to reduce cost. Does anyone else on the Committee want to address that question?

MR. V. E. BROMAN [Project Engineer, Arco, Harvey, Illinois] Jack, have you considered what the effect would be if you use that 7500 vis No. 6 diesel fuel to make your blends? Would an increase in injector pressure help to utilize fuel somewhat better?

MR. HOFFMAN: I interpret the question to be: Using a fuel that actually has a viscosity of 7500 rather than using that as part of the blend.

MR. BROMAN: Part of the blend. A fuel like the blend suggested is used in marine engines.

I am wondering whether or not there is any proposal to utilize much more pressure through the injector to get better atomization and better burning.

MR. HOFFMAN: As you increase the viscosity of the product going through the injection system, at least with our jerk pump nozzle configuration, fuel pressure is increased. Injection pressure is therefore increased. It is possible for increased pressure to affect combustion positively or negatively. It can give better atomization; and if there is no other side effect, that could result in more efficient burning. (Obviously, you have to contend with increased loads on camshafts and the like.)

On the other hand, increased pressure can also change the penetration into the cylinder, and we could begin, in an unmodified or unspecified design, impinging the product on piston crowns or impinging the product on cylinder walls, and really worsen combustion. So, there are both sides.

The answer is yes. I point out, however, that a 30 percent blend of 7500 second fuel with 70 percent No. 2 would have a viscosity of 50 to 55 seconds at 100 degrees Fahrenheit. That is about the way the blend would come out. I did that in my head. It is pretty close to that value.

MR. J. F. HILLARD [Technologist, Texaco, Beacon, New York]: First, I would like to commend GE for doing this work on what appears to be a lower cost fuel option for the railroads. I would also like to tell you that Texaco throughout the free world does provide blended fuels for marine use.

I would also like to point out that there are going to be tremendous problems if the railroads throughout the United States try to get this blended fuel. The places that we supply it for marine use have heated tankers going into them, and heated facilities, and other proper facilities to handle this fuel, whereas throughout the inland United States this is not the case. The pipelines are out as far as transmitting black oils, as Jack alluded to.

While I have our company experts still looking into the situation, one oil company at least does not feel the future supply of residual fuels, if you will, will be quite as General Electric sees it. I am not going to throw cold water on any means you railroad people have for reducing your operating expenses, but I did want to point that out.

Incidentally, I was surprised to see that slide a while ago. We really haven't had much time to look into the supply situation, but what I have told you is the feeling that we have now. If our company experts come up with anything different, we will let you people know.

MR. HOLMES: Jack, in regard to the availability, what does Texaco see as competition for the black oil? We are now aware that a number of oil companies use this type of oil possibly to make high-grade electrodes. On the other

hand, the utilities apparently are going off of the heavy oil, which is steadily increasing the supply. What are your thoughts on that?

MR. HILLARD: I don't have our experts' answers yet, but as we see it at this point, there is going to be more and more cracking (or other upgrading) of residual fuels to supply a No. 2 type diesel fuel. I am not saying everything we crack will be a No. 2 as you see it today, but fuel that is close to the No. 2 that you are burning today.

In addition to that, many of the crudes that will be available are going to give you a poorer and poorer source of usable residual fuels, so we think there will be additional cracking as the poorer crudes become common. As of now, that is the way I see it.

I would like to defer any detailed question like that. As I said, the company experts are looking into the situation. I am not prepared at this time to discuss all the details.

MR. G. C. McCARTY [Technical Engineer, EMD, LaGrange, Illinois]: I would like to add one thing that has not been mentioned, and that is that there are other characteristics of blended fuel that could damage an engine, such as vanadium and catalyst fines. EMD has looked at quite a few blended fuels and hasn't seen any of them that were void of all of the characteristics that could be harmful to the engine.

EMD has done quite a bit of testing, as has GE, and has been involved in several field programs. We just want people to be aware that using blended fuel may not be as simple as it sounds, and that they should approach it very cautiously.

VOICE: On the subject of residue, I would like to address a question to the engine builders, both 4- and 2-cycle. Are you doing anything in the area of limiting injection into the system? I believe the process is called fumigation. It has nothing to do with pest control, but is a way of stretching the fuel.

MR. HOFFMAN: We are not doing anything that we care to discuss at the present time.

MR. McCARTY: That also goes for EMD at this time.

MR. HOLMES: Any other questions? If not, we may have some spare time at the end of the presenation, and if you think of any other questions on any of the subjects by the time the whole paper is given, please feel free to bring them up at that time.

[Mr. R. A. Bjorndal, Senior Staff Engineer, Chevron, San Francisco, California, summarized Part I of the paper.]

MR. HOLMES: Are there any questions from the floor on this subject, or any comments from the panel on any aspect, or from the engine builders in regard to their particular situation relative to this development?

PRESIDENT BRUNER: There is supposed to be a teflon coating deposited on liners and other surfaces. We hear a lot of claims. What do you people think about it? Have you progressed any work in this area, or would you even consider it?

MR. HOFFMAN: The only comment I would care to make to Frank's question is that first we have looked at an extremely small number of available special additives to lubricating oils. That small number we have looked at has fallen short of their goals, but the more important thing is that it is broadly our view that any chemical additions to the lubricating oil, as well as to the fuel oil, is best done by the supplier of the product.

A major area of concern here is, assuming the additive material were to perform specifically the function for which it was introduced, and did it as well as the developer hoped it would, those chemicals which are being introduced would upset the very careful balance of chemical additives which have been introduced to help the lubricant perform its other functions. So, we have (a) a limited experience, (b) the small amount of experience has not been successful, and also (c) we believe those types of things should be done by the oil companies.

PRESIDENT BRUNER: Would EMD like to say something about this?

MR. McCARTY: We basically follow the same pattern. We do occasionally get inquiries on the use of additives. There has been a program set up by the AAR in cooperation with Southwest Research Institute in San Antonio, Texas for anyone who would like to test additives. We generally refer inquiries to SWRI for any supplier who would like to test an additive at his own expense.

Tom Pratt, do you have any comment on the use of additives?

MR. THOMAS N. PRATT [EMD, LaGrange, Illinois]: I think there are two separate things we are talking about here at the same time. One is fuel additives, and that is a program that Jerry referred to that Southwest Research has. The second question I think Frank asked was relative to teflon — for example, a teflon coating on a liner. Teflon coatings have been discussed in the past, and I don't know of any such thing that would hold up in an engine of our size.

There are some limitations on temperature. Teflon has heat limitations, and in general the operating temperatures and pressures that exist in the railroad type diesel engine, I think, would be inclined to remove such a coating. Most of these types of coatings, I believe, might be effective on smaller engines—lawnmower types, and so on—if they are, in fact, effective at all.

PRESIDENT BRUNER: I wonder if the oil companies have anything to say. However, before they do, I understand two additives companies have approached Southwest Research. However, Southwest Research has elected not to upset the basic engine parameters with additiyes until such time as the alternative fuel tests have been completed. Would one of the oil companies like to address this?

MR. BROMAN: One of the key points made by Mr. Bjorndal was that when they performed their tests on fuel efficient lube oils, what they were looking at was principally viscometrics. Viscometrics have a great deal of promise in large engines which operate mainly in the hydrodynamic mode, that is, with a lubricant film between the parts.

He made another point. The best place to look for effective use of a friction modifier is in the boundary lubrication area. This is logical, because in the boundary lubrication situation surfaces are in rubbing contact and a friction modified film on those surfaces can reduce sliding resistance.

I certainly don't believe the railroad locomotive or any other large engine working in the hydrodynamic lubrication area will show a great deal of improvement simply from using a friction modifier, since there is no surface where a friction modifier could help reduce friction.

MR. AXELSON: I would like to clarify one point — the reference to the Southwestern test laboratory specifications for fuel additives. Those rigid specifications were set up by the AAR for guideline use by concerns such as Southwest Research, and the AAR specifications are available for all interested to see and get copies of. That of course is a joint effort, as you mentioned, Jack, between people like the LMOA and the AAR Locomotive Committees. I just wanted to make sure the record is straight on that.

MR. E. C. YOUNGHOUSE [Exxon Company, Houston, Texas]: I represent the oil company that did the work with the friction modified lubricant. I don't concur with the statement that diesel engines do not respond to friction modifiers.

We have had experience with a variety of diesel engines that have responded to the friction modifier systems. One of the factors that develops is that passenger car gasoline engines are operating in very lightly loaded conditions, and an improvement in engine friction will result in a sizable percent reduction in fuel consumed. But if you take a locomotive or diesel engine operating under heavy load, most of the fuel is being burned to develop power, and only a small amount to overcome friction. So, if the oil overcomes part of that friction, it is still going to be a small portion of the total fuel burned. Improvements can be difficult to measure.

A comment was made about the durability of friction modifier systems. We have had quite good success in gasoline applications and in high-speed truck diesel applications. Also, we have evaluated the friction modifier system in service in medium-speed diesel engines for 10,000 hours with good success, i.e., with no effect on deposits, wear, or used oil properties. So, we feel that our friction modifier systems are effective and can be applied in diesel service.

PRESIDENT BRUNER: There have been two things taken up during this discussion. One is the friction modifier, which I wasn't particularly referring to. The other is a "claimed" teflon coating of the bearings by way of teflon additives in oil. If we don't have an answer to that particular question now, we might consider it for next year, or maybe we can bring it up at the What's Your Problem this year.

MR. HOLMES: May I further clarify and partially answer Frank's question. I don't believe any of the oil companies involved used soild lubricants as friction modifiers in their testing; is that correct, other than gasoline? Am I correct in the assumption that neither have they been used in gasoline? Ed, does your work involve solid lubricants? You said a medium speed engine had 10,000 hours on it. What kind of additive was it?

MR. YOUNGHOUSE: We didn't study solid lubricant (dispersions) in depth. Our friction modifiers are oil soluble materials. The solid lubricants are dispersions of materials like graphite or molydisulfide, which have been used with differing degrees of success. I can't comment on the use of teflon since I have had no experience with it. Perhaps somebody else can discuss it.

MR. HOLMES: Gene, in Arco's use of the solid lubricants, wherein you have evidently met with some degree of success with the graphite additive in gasoline engines, why wouldn't that be applicable in a diesel engine?

MR. BROMAN: The use of graphite in diesel engine oils has been successful, but we must distinguish between the type of diesel engines we are talking about. In high-speed types, operating around 2200 RPM, rubbing contact is affected by a friction modifier and will respond to solid or soluble types. The medium-speed engines operating in the hydrodynamic or thick film regime do not respond to modifiers. They respond to the ease of shearing of thick oil films. Multigrade oils shear, and the lower viscosity will give a small amount of fuel savings.

[Mr. E. A. Goff, Industry Sales Executive-Railroad, Mobil Oil Corporation, Naperville, Illinois, summarized Part III of the paper. Mr. W. H. Melgren, Assistant Engineer of Tests, Burlington Northern, Springfield, Missouri, summarized Part IV. Mr. Broman summarized Part V, and Mr. McCarty summarized Part VI.]

MR. HOLMES: Are there any questions regarding these subjects?

MR. WAYNE EWING [Altoona Gear Company, Los Angeles, California]: Does this new seal cause a remachining of the hub and seal areas, or does it fit on the gear as it is?

MR. McCARTY: There is no change in the gear. The case has to be modified, and that's all.

VOICE: I think you have made some fine improvements on the axle. Are there any developments

on the pinion side of the new type of seal?

MR. McCARTY: I am not sure. There is a gentleman in the rear who may know more about that. Paul, how about that?

MR. PAUL BIEN [EMD, LaGrange, Illinois]: In answer to the question, I can only say we have nothing we are ready to talk about at this time.

MR. HOFFMAN: One brief comment with respect to fuels. This being an international gathering, I realize I neglected to indicate that our Canadian friends have been experimenting with blends of residual type fuels and distillate fuels for about a year, and have been experimenting on a broader basis than the small number of units that been involved in this country. I don't think there is a representative here of the Canadian system that is doing the work. However, if I missed him and he would like to have an opportunity to comment, he will certainly be welcome.

MR. HOLMES: I would like to ask a question of some of the oil company people with regard to the sodium grease in the gear case. Is the gear case going to be sealed as tight as Jerry McCarty described? There has been a sudden rush of some railroads back to using sodium greases. Is the sodium grease indeed going to be oxidation resistant enough without any renewed grease?

Do any of the oil companies have any comment on the comparison between the oxidation resistance between the two types of grease? Would you also discuss a comparison of EP properties? The lithium grease definitely has EP properties, provided by an EP additive, and to my knowledge the sodium grease still does not have an EP additive in it.

MR. WILLIAM RUNKLE [Ashland Oil Company, Ashland, Kentucky]: I have a couple of comments with regard to sodium grease. With respect to oxidation, I am not sure we really know whether it has sufficient oxidation inhibition, whether it is superior to lithium or not equal to it. I think primarily you are looking at the oxidation characteristics of the base oil as opposed to the grease soap, particularly at the low percentages of soap concentration concerned. However, if additional oxidation inhibition is required, it can be put in to meet that requirement.

With respect to the EP additives, they can also be added to the sodium soap greases if they are required, so there is no reason why they can't be there. They are presently not there, I suppose, because with the original heavy viscosity oils they were not required.

MR. HOLMES: In regard to Gene's remarks about the lithium-sodium combination and the calcium complex, it appears that the industry might be ready for such an alternative. If these are indeed superior greases for this application, are the builders aware of this, and is there any communication going on between suppliers and builders? It seems we are at a status quo, and such an exchange

of ideas concerning different types of greases with potential doesn't seem to be going on. Could anybody address that subject?

MR. BROMAN: I might attempt it. I don't believe there is any rhetoric between the builders and the suppliers. If you noticed in the report, these greases were suggestions and were proposed based on grease properties.

There is a big difference between the formulation of a traction motor type and regular greases. That is the base used. There are at least two different approaches. One uses an asphaltic material and the other uses a petroleum resin. These two bases have a great deal of influence on how the greases themselves will perform under both operating and oxidizing conditions.

The question to be resolved is whether or not the calcium acetate, calcium complex, or certain mixed greases would perform if they were made using these particular bases. Both bases cause structural changes in grease gel when compared to regular greases. None of this type of work has been done.

MR. G. L. KARNER [Gulf Research & Development Company, Pittsburgh, Pennsylvania]: There are better protectional greases available. There are candidates that look very good. I think many of the oil and grease suppliers are in a position to present these. Some are polyurea thickened materials. Everything looks good except the price. The last time we checked it out, the price involved was about three times greater than I think the average 47½ cents a pound package price the railroads are paying. If anyone is interested in better materials, potentially they are available but they are more expensive. If anyone wishes to contact me personally, I will be happy to discuss it with him.

MR. W. C. SCHICKRAM [Senior Product Engineer, Conoco, Ponca City, Oklahoma]: I might comment that as seals are improved in gear cases, oxidation stability becomes more important in both lithium and sodium soap thickened greases. We need to remember that the reason for the lithium or sodium soap is to keep the grease in the gear case. It offers nothing as far as actual lubrication of the gears is concerned. As the seals are improved, the need for the soap thickeners may lessen.

We need to look to the base oils used to help provide the low temperature characteristics needed for cold weather operation. At zero degrees, many of the present greases turn brittle in the gear case, therefore they provide no lubrication.

As retrofitting of improved seals becomes more widespread, we will see greases with better oxidation stability and better low temperature properties.

MR. BROMAN: Ultimateily, then, if traction motor gear cases become as efficient as they probably can, we may go beyond the grease stage to a gear oil stage. Low temperature properties as well as EP characteristics would be considerably improved.

VOICE: I would like to ask whether in testing the multigrade oil there was a noticeable increase in oil consumption compared to the straight SAE 40 grade.

MR. BJORNDAL: Keith, can you speak to that?

MR. KEITH PARKER [Chevron Research, Richmond, California]: The locomotives were equipped with onboard lubricating oil tanks and levolators. We could see no significant increase in oil consumption with the multigrade oil.

MR. HOLMES: Any other questions or comments on any of the subjects? I have one final one for the benefit of our associates and friends who aren't here, who will probably read the proceedings with interest.

I would like to ask the General Electric Company what the status is in their testing. When I was at Erie recently, with the LEE committee, it was my understanding that by midsummer the status of the lithium lubricant that was then under test would probably have been evaluated. Has this been done, and has it been accepted or rejected? If it has been rejected, are you going to continue to test lithium gear lubricants?

MR. FORREST MITCHELL [General Electric Company, Erie, Pennsylvania]: Our in-house testing is now six months older, and results are not as promising as the results we got with the jet TM sodium base lubricant. The test we were running was on the jet TM SLH, which was the high viscosity lithium based lubricant. The test results on the gear setup, where you gear one motor into the other, were not as successful as the results originally achieved with the standard jet TM.

One southern railroad also participated in using the SLH lubricant in actual road service, and the results they observed were not as good as the standard jet TM sodium base, and they have switched back.

We would at this time certainly like to continue the testing, Dick. What I have heard so far sounds like it is something the builders should be asking. I will try to state that now.

The gear cases are improving. The seals are improving. The duty cycle is increasing. The ability to hold the adhesion has increased by both builders. There will be heavier loads subjected on the gearing. This means that we are having difficulty with the lubricants available today. There certainly will be more difficulties down the road unless an improved lubricant is made available.

I want to look up the gentleman from Gulf, because we are certainly interested in improving our lubricant in the test set in Erie, because I believe in the future it will be required in higher adhesion locomotives.

Dick, there is a test being conducted by the Santa Fe Railway. I don't have the results of that test. They were making an attempt in actual road service to compare the locomotives with different lubricants in the gear case on a con-

trolled test. That should be made available to the Committee, and I assume it will be.

MR. HOLMES: Jack Embrey, I know you mentioned it. Do you have any tentative reports on that, or any preliminary reports?

MR. JACK D. EMBREY [Manager-Chemical Services, Department of Technical Research and Development, Atchison, Topeka and Santa Fe Railway Company, Topeka, Kansas]: We do have a test under way, and we had a traction motor teardown just this past week. The information is not available but will be very soon. I will say that probably our test at this point has raised more questions than answers, and no doubt we will probably want to continue the test further.

This particular test, I believe, is being discontinued because particular consist units are being put into other service. Hopefully we will have an update on this test at our next meeting, and I can give you some positive information later.

MR. HOLMES: One final thing on traction motor gear lubrication. I do know it is still on the agenda of the LEE committee, and will be discussed again at their next meeting. I hope both engine builders are listening and are making progress to resolve the problems involved.

We are trying to arrive at a common standard and specification that is practical for the railroads to ensure that they receive a good quality product that both builders can live with.

We also need, as has been suggested in a recent article, co-authored by gentlemen from Arco Oil Company, a comparatively simple type laboratory bench rig which, apparently, can be an excellent screening device. There also are much more expensive screening devices, such as the FGC test machine built and designed in Germany that is an excellent forecaster of gear tooth wear as related to lubrication.

We know that each builder has his own in-house test methods. Both have a lot of experience in that area. However, when the specification and standards subject for traction motor grease is progressed, it is necessary to make a cooperative effort similar to that made by the joint AAR-Industry development of freight car roller bearing greases. True, a budget would have to be allotted for necessary test equipment at the AAR laboratory, if it can be agreed that the AAR approve traction motor gear lubricants for common usage in all locomotives.

This controversial situation has stayed in limbo for several years. At the last meeting of the ad hoc committee it was strenuously expressed that field tests are logistically unfeasible for railroads, considering present type of operations. Therefore, we need some absolute type of in-house testing that would reasonably predict field performance. I can't emphasize that point too strongly.

If there are no further comments or questions, I will call on Dave Goehring, Regional Executive, to summarize the paper.

MR. GOEHRING: The Lubricating Committee has demonstrated its ability to provide one of the most professionally prepared pappers in the LMOA series. It is not only well prepared but also very well presented.

The energy-saving benefits from proper lubrication of locomotives, when added to all the other fuel saving devices that have been talked about to date, may mean the railroads should be able to soon start giving oil back to the oil companies.

Seriously, the discussion on the various alternative fuels and their development is progressing over the years and is interesting to all of us. The effects of various fuel properties, such as viscosities and cetane numbers on engine performance, are important, and our properties maintenance personnel will have to be aware of this.

The review of field tests and what has been done to date was timely and interesting. The energy conserving properties of lube oils and the use of friction modifiers is important. It is essential that these are being discussed, because not only do railroaders read about and talk about additives but they have been a topic of discussion for a long time in the automobile industry. I think a lot of us have a tendency to be Doubting Thomases about any beneficial effects of those substances when added to lubricating oils. It is good to learn that these substances are being tested and that we are getting some positive results.

The effect of the low aniline point on oil on EMD journal box donuts is something that was interesting to me, because we have had those problems on our railroad. For those who are here from the railroad industry, this type of enlightenment is one of the reasons we attend these meetings.

The traction motor gear case lubrication problem, which has been with us for several years, is slowly being resolved. We have heard several very positive comments. I like what I am hearing about what is being done to determine the effects of different types of lubrication, and also in the development of improved sealing materials.

The comments associated with this particular subject have lengthened this session an additional 45 minutes, which indicates that a lot of people in this room are extremely interested in lubrication problems.

I think the comments made by one of the builders' representatives about the pressures that are being brought to bear on the gears, not only now but in future designs, are a challenge that has not been met yet and will therefore continue to face us. I am encouraged by what I have heard here today, by the way this subject was presented, and by the fact that the gear problem is being addressed.

Now I will turn the meeting back to Dick Holmes. [Applause]

MR. HOLMES: Thank you for your applause. The Committee certainly deserves that for their contribution today.

PRESIDENT BRUNER: All I can say is that this has been quite a meeting. A lot of interest has been shown by many of you in the audience.

It has been a real pleasure to have all of you here this afternoon. Let's give the Committee and Mr. Holmes and Mr. Hudgens, who couldn't be here, and all the Committee members a rising vote of thanks.

[The audience arose and applauded.]

[The meeting recessed at 4:25 p.m.]

WEDNESDAY MORNING SESSION
September 22, 1982

WHAT'S YOUR PROBLEM PANEL

F. D. BRUNER, Presiding
PRESIDENT
Asst. Chief Mechanical Officer-R. & D.
Union Pacific Railroad
Omaha, NB 68179

The meeting reconvened at 8:35 a.m., Mr. Frank Bruner, President, presiding.

PRESIDENT BRUNER: Because there is no one here from the Committee on Diesel Material, we will recess until ten o'clock for the What's Your Problem session. This particular session will be cancelled, and we will start the What's Your Problem session at ten o'clock.

[Recess.]

PRESIDENT BRUNER: While we are assembling, we have some VIPs from out of the United States with us, and I would like to recognize them at this time. Mr. Mohler and Mr. Oakley, from the Danish State Railways. Mr. Mohler is Mechanical Engineer and Mr. Oakley is Assistant Chief Mechanical Engineer. Will you two gentlemen stand, please? It is certainly a pleasure to have you here. [Applause]

Also, Mr. Fairweather, Consultant, from London. Is he here this morning? [Applause]

It is indeed a pleasure to have you people here. During the session we might take advantage of you. Maybe some of our people have questions for you. I am certain, from reading the Railway Gazette and a few of the international magazines, that a lot of progress is being made in the railroad fields around the world.

This is the What's Your Problem session. Who is going to be the chairman this morning? Am I elected? I will delegate myself. Okay?

We do have some of the committee chairmen here on the podium, and we hope we will have people to field the questions you may have. Also in the audience are a few representatives from the engine builders and oil companies.

At this time we will declare the session open for questions. Is there anything you might like to discuss? We will not try to drag on this session. We will adjourn as quickly as we can, for the benefit of those who want to get away early or who have other commitments. I do want to say that I appreciate the fact you are all here and have come to the sessions and have participated. We have certainly enjoyed that, but I don't want to prolong the meeting.

We are ready for questions from the floor, if you have any.

MR. CUMBEA: I might open with a question or two. I am very much concerned with the number of locomotives that are stored throughout the industry now. We have some problems with storage of locomotives. One that we are aware of is the potential of the loss of stability of fuel when you store locomotives with the tanks full of fuel. Are there any oil companies present that could give us any recommendations on additives or how long we can store a locomotive with a full tank of fuel?

MR. HOLMES: We have taken samples recently out of some of the locomotives that had been stored, with the longest period being close to a year. The fuel had degraded slightly. In most cases we decided to evaluate additional samples of fuel again in a couple of months. It is difficult to sample all units in storage periodically, because of the numbers involved. To get them all at one time is almost impossible.

The other approach would be to sample all units when they are removed from storage. We can then look at the fuel just before the units are brought out of storage. Deteriorated fuel oil could be pumped out of the locomotive tanks as needed.

We use a package treatment which is put into fuel oil. This is a combination biocide, stabilizer and anticorrosion inhibitor. We "slug" the fuel tanks with this additive, Nalco 2210, prior to storage. Additive concentration used was about 300 parts per million. That is about a gallon of the fuel treatment per locomotive fuel tank.

The fuel oil in stored locomotives definitely deteriorates to a degree, depending upon time. Fuel color is a good, simple indication of extent of deterioration. We use a short-term, accelerated heat test at 300°F, commonly referred to as the Nalco 90-minute test. Condition of the fuel can readily be observed by the color of filter pads used in the laboratory procedure after the fuel has been heated. Comparison with color standards indicates degree of stability (or degradation).

MR. CUMBEA: I have another question on storage, Dick. I am not sure anybody here can answer it. There are several complete plastic covers available on the market to be placed over the diesel locomotive. I am wondering if anyone has had any experience with these covers. What are the safety aspects of removing and applying the covers? Are there any problems encountered with potential sweating — moisture problems if the locomotive is completely covered? There was a picture in one of the recent publications of one of the Canadian railroads that had several locomotives in the line with covers over them.

PRESIDENT BRUNER: In Science magazine I read that in Germany they are storing convertibles for the future, and are putting them in plastic bags and then inserting a gas to encapsulate the car. That is a little vague for a locomotive. What we are trying to do is keep them down South where it is nice and sunny.

I might mention to Dick that if you are interested in how many

Attending our Official Family Annual Luncheon, and pictured here, were our three recipients of the LMOA Outstanding Associate Award. Left to right: Marty Hausman, President, Power Parts Company; Roy Touchstone, President, Touchstone Railway Supply & Manufacturing Co., Inc.; and Nick Eckerle, Sales Manager, Specialty Chemicals, Nalco Chemical Company.

samples we took, since we had over 500 locomotives stored, we asked that at least a 25-locomotive sample be taken. We sent those to the laboratory, and I believe about six of the 25 showed some deterioration. Based on their location, where they are stored, and the manpower, we elected to ask the mechanical superintendents to sample the fuel at the time they anticipate the locomotives will come out, and get it to the laboratory. Hopefully we can tell them at that time if we think it will be successful to run with that fuel, or if the fuel should be taken out and put in powerhouse service.

It is certainly a loss of fuel and a loss of effort. We have elected to keep our tanks full to prevent rusting. We have a lot of fuel stored in locomotives. It is a large amount of money tied up in fuel, but if we let those tanks sit there and rust we will probably find more trouble.

Any further questions along that line?

MR. HOLMES: In our procedure for storing locomotives, we generally follow the engine builders' recommendations, such as the antirust put into the cooling system plus the fuel oil additive. Also, the fuel tanks are completely filled.

Do the engine builders have any comments concerning protection of the engines stored according to their recommendations for long periods of time? Would the moving parts of the engine, the water system, fuel system, and so on, be sufficiently protected for an indefinite term? What areas would you expect might rust, as Bud inquired about? Do the engine builders have a comment?

MR. MITCHELL: We have a GEI that describes the place of storage procedure, which I am sure you are aware of, and it covers all areas of the locomotive, basically the engine fuel system, lube oil system and electrical components. Unfortunately we have to rely on someone else's experience, because we don't usually keep our engines stored.

However, we do recommend that each year the locomotive remains in storage you pull it out, clean it up, start it, and repeat the regular storage procedure. We do that, and it is probably conservative, simply because we do not have enough experience to know which is right and what will happen in the second or third year of storage.

I am very interested in what the Union Pacafic proposes to do, which is to take locomotives that have been stored for a year or a year and a half—ten of them—and go through them and find out what has been damaged by moisture or whatever. I think that would be excellent information to share with the industry and the locomotive builders. We simply do not have that knowledge. We are looking at locomotives that have been in storage for two years or more, and I don't know of anyone who has first-hand experience as to what occurs at that point in time.

PRESIDENT BRUNER: Bud, you brought your locomotives out of service and put them back in service and rotated them, didn't you?

MR. CUMBEA: We were on a six-month cycle, placing stored locomotives back in service and substituting other locomotives, but we have found this creates some problems. Now, at each of those six months we check the batteries, run the engine, and put them right back into storage.

There is another product we are evaluating that looks like it may have some merit. I have no technical information on it at all. It is called Z-Rust. It is a small capsule that you can put in an electric locker. It gradually emits a vapor which protects the electrical contact areas against corrosion. It is supposed to have a life expectancy of about two years. It looks very good, and we have purchased some for test.

MR. BROMAN: One of the things we have recommended to a Midwestern railroad but don't have a great deal of practical experience on, is the use of saci-sulfonates as rust inhibitors. Saci-sulfonates are dispersable in fuel. When the fuel

Taking part in the 1982 Annual Technical Conference were, left to right, LMOA Past Presidents John W. Hawthorne, (1949), retired from Seaboard Coast Line; Ky Pruchnicki, (1972), retired from Southern Pacific; and Larry Booth, (1975), retired from the Chessie System.

tank is drained the sulfonate coats the tank sides with a protective barrier film that resists rusting.

So far, it looks like the method has been successful in controlling rust.

MR. SMITH: Have you found it necessary to move stored locomotives periodically to protect the journal bearings, and have these locomotives that have been stored for a year had batteries on board?

MR. CUMBEA: On the Chessie we generally do leave batteries on board on stored power. We do make periodic checks of the specific gravity of the batteries to make sure they are being maintained properly.

As far as the brinelling of the axles, our policy also is that the locomotive should be moved a few revolutions at three-month intervals, which is in line with the builder's recommendations.

MR. CHIRIKOS: Concerning your comment of taking them out of storage, starting them up, and then putting them back in storage, what procedures do you go through along those lines? Is that with Tectyl in the oil pan, and do you start them and run them with virgin oil?

MR. CUMBEA: We are just using the short-range storage procedures recommended by EMD, and at six-month intervals we start them up. We do not use Tectyl.

MR. CHIRIKOS: Usually, when you say "short-term," one never knows how long a short term would be. We would caution that if you have Tectyl in the engine, don't disturb it, because once you disturb it you might be setting yourself up for problems.

PRESIDENT BRUNER: We will have to go back and look at our situation on that matter.

Any further questions? If there is anyone in the audience who has a question, please remember we want you to feel it has been worthwhile to come to this meeting. I feel that the papers given in the last couple of days have been splendid.

This morning no representative was here from the Material Handling Committee. If anyone has a question in that area we will be glad to try to answer it. One gentleman came up and asked about the use of kits. We will give him that part of the paper to read. We have tried to be as helpful as possible under the circumstances.

MR. SMITH: I will throw in another question. This is about the various improved exhaust manifolds. Have these manifolds that were described with the reduced back pressure, retained all the spark arresting features that the previous generation of manifolds had? Do they still have the retention traps? Has anyone come up with a self-cleaning arrester by any chance?

PRESIDENT BRUNER: If I am not mistaken, I think Farr advertises a manifold of that type.

MR. ED KORTE [Farr Company, El Segundo, California]: I would like to say that our manifolds are U. S. Forest Service approved spark arresters. They are not self-cleaning. We have not yet been able to set up a self-cleaning spark arrester. They still have the retention traps on the side.

PRESIDENT BRUNER: Have you been working on the possibility of a self-cleaning unit, or thought about it?

MR. KORTE: Yes, we have.

MR. HOLMES: I have been thinking about this, and wondering what the progress now is in the field with what used to be called the Model 200 fuel oil filter. I understand one engine builder is putting it on as original equipment. Are you getting six months' life out of that filter, or more? What is the efficiency of it?

MR. KORTE: GE is using the model 200 fuel filter as standard. It is the filter that was recorded the other day, that goes with their new parallel fuel system. It is 10 inches in diameter, contains 200 square feet of filtering material, and that is 150 square feet in the first stage and 50 square feet in the second stage. It is now available from EMD also on the larger locomotives as one of their standard three options. Their standard three options, as we understand it, will be the single 6-inch by 29-inch element, or two of the standard elements in parallel, or one Farr Model 200 fuel filter.

I might add also that we are working presently on a system that would utilize this same filter in the lube oil of the locomotive and be able to easily provide the railroads with a 92-day lube oil filter change. That system would contain four Model 200 elements rather than seven of the 6-inch elements, like they use on the EMD, or ten of the 6-inch elements that are used on the GE.

As far as life is concerned, we are seeing easily 92 days on the fuel oil filters, and we have seen them last as long as nine months. They actually have a capacity of nine times the standard 6-inch element.

MR. CHIRIKOS: I will confirm what the gentleman from Farr said about the three options from EMD. We have the single 6-inch element, two 6-inch elements as an option, as well as the Farr 200 filter. In the single or dual 6-inch application there was the practicality of being able to have those types of elements available, since they are used on so many locations onboard the locomotive, not only in the fuel system but the lube oil tank as well, and the electrical cabinet air filter.

PRESIDENT BRUNER: Are there any other questions this morning?

MR. HOLMES: I have heard some interesting stories about engine air filtration. This subject is usually handled by the Diesel Mechanical Committee. I was wondering if the engine builders or filter manufacturers have accumulated any new data about wear rates of paper engine air filters compared to fiberglass. Is there any recent railroad test experience?

It is my understanding a recent claim for paper filters is ability to filter out finer particles.

PRESIDENT BRUNER: As I understand it, the Santa Fe made a study on the assembly life, and it seemed to favor the paper filters. Since the Santa Fe doesn't have anyone here to answer that question, we might have to wait until next year. Maybe one of the suppliers can let us know.

MR. KORTE: I think it probably would be better if someone from the Santa Fe could specifically answer it. Mr. Jack Hatfield, Director of Locomotive Maintenance of the Santa Fe, did conduct such a study during the winter of 1981-82, and the railroads that participated in that study all received the results of that survey. Perhaps Mr. Hatfield should be asked to report on it.

I think it has generally been known that the paper filter does take out finer particles and is a little more efficient than the fiberglass filter. As far as I know, the Santa Fe study is the most current study of the results on wear.

PRESIDENT BRUNER: Thank you. I am not familiar with that information, and haven't received it in my department.

MR. DATHAN: On your question about filters, we are using the fiberglass body filters on the LRC Locomotive, and when the filters are dirty or loaded with snow we get a certain amount of shrinkage

On his retirement from railroad service, and in recognition of his years of outstanding service to LMOA, Kjell "Swede" Axelson, right, is presented the General desk set by Past President L. H. Booth. President Nelson Buskey, center, gives smiling approval.

of the fiberglass. It is obvious to us because we frequently walk through this locomotive in service. We don't know exactly what is causing it, whether the operators are overrunning the change periods. It is something we have observed in the last few months. We thought it was originally just snow, but we have seen it with dirt in the summer, too. Under those circumstances it is obvious the paper filter might work a lot better.

MR. FRANK BOATWRIGHT [EMD, LaGrange, Illinois]: As a matter of interest, we have recently delivered some locomotives to Mauritania. Mauritania is tremendous as far as sand is concerned. Right now we are running some tests between fiberglass and paper filters. More will be known as time goes on, and we are learning a lot about our own locomotive and its carbody tightness and integrity when it comes to sandstorms and things like that.

One major complaint we have had from the railway (and this has nothing to do with the particular manufacturer of the filter) is that they can't install the filter and ensure its integrity. It happens to be the paper filter. So, we are testing them both. With the fiberglass filter we have a visual assembly integrity of the filter.

I noticed in talking to the Farr Company that they have a new instruction out now as far as installation instructions for the paper filter, which is very good and which will help our customer. By next year we will know a lot more about paper and fiberglass filters being operated in deserts and under similar conditions.

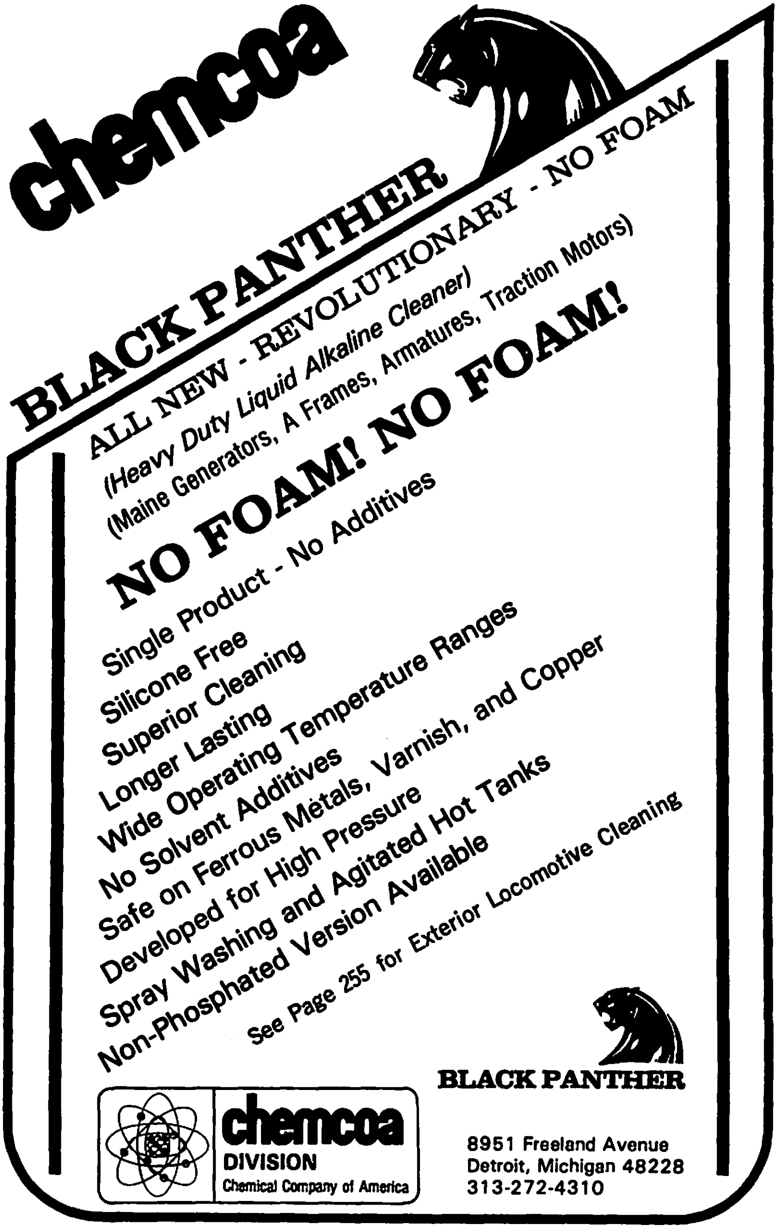
MR. CHIRIKOS: Along the lines Frank indicated, I think our policy right now is that we consider all three types of filters — the Donaldson, the Farr and the American — as equivalent at this time unless tests show something else. I believe our ratio on new locomotive deliveries is three to one on fiberglass bags as far as original equipment application is concerned. That is the customer preference, and whatever the customer dictates is what we put on.

MR. GOEHRING: Has there been any further development or interest in a traction motor support roller bearing? Is there anything being done, or is there any interest in it at all?

PRESIDENT BRUNER: A number of years ago we ran some roller bearing support bearings on some gas turbines, but that was long ago. Does anyone want to discuss that?

MR. CHIRIKOS: I think we answered that last year, Dave. We have the E-88 traction motor on the GM6C that has the roller suspension bearing. To my knowledge we haven't had that many inquiries from customers wanting it as original equipment, but it is a cost-related item and the cost is significantly higher. That is the input we gave it at last year's Mechanical Committee meeting.

MR. MITCHELL: As you know, we have in service traction motors with the antifriction support bear-



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men? If not, we will close the meeting for this year.

I want to express our appreciation to you faithful suppliers, manufacturers and representatives here. We appreciate it very much. We would have had to cancel the meeting if it hadn't been for you people.

I am sorry I didn't get to all the hospitality rooms, but I assure you there is one thing we do on the Union Pacific, and that is to welcome you people. You are the ones who provide us with the equipment to keep us going. You people are welcome any time.

The meeting next year should be a very good meeting, and we are looking forward to it.

Unless anyone has one last statement, we will adjourn for this year and see you in 1983. Thank you. [Applause]

[The meeting adjourned sine die at 10:45 a. m.]

PRE-CONVENTION PRESENTATIONS

INDEX

LOCOMOTIVE MAINTENANCE OFFICERS ASSOCIATION

MONDAY, SEPTEMBER 19, 1983

TUESDAY, SEPTEMBER 20, 1983

WEDNESDAY, SEPTEMBER 21, 1983

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LADIES FREE

Our registration desk, located in the Normandy Lounge, Second Floor East of the Conrad Hilton, Chicago, will be open Sunday, beginning at 12 noon. Come in Sunday afternoon, register, and enjoy this special opportunity to visit with our officers and your other friends. THIS WILL SAVE YOU VALUABLE TIME ON MONDAY MORNING. KEEP YOU OUT OF THE REGISTRATION RUSH. **BRING YOUR WIFE WITH YOU.** She will enjoy the special entertainment planned for her!

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1. **STUDY these reports closely.**
2. **SEND OR BRING written questions to the Committee Chairmen.**
3. **BRING THIS BOOK TO EVERY SESSION OF THE ANNUAL MEETING! There are no extra copies.**
4. **BRING your 1983 LMOA Membership Card for identification in registering.**

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Please do not embarrass your Supply Company friends by calling at their suites while the meetings are in progress; it will cause them:

1. **To remind you of this ground rule.**

   or

2. **To lose their reservation at this meeting, and to forfeit their right to attend future meetings.**

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OUR OFFICERS

F. D. BRUNER
PRESIDENT
Asst. Chief Mechanical Officer-R. & D.
Union Pacific Railroad
Omaha, NB 68179

MEMBERSHIP THRU THE YEARS

	Advertisers	Associate	Active	Total
1939	0	27	60	87
1940	34	48	162	244
1941	38	48	210	296
1946	103	187	676	963
1947	101	284	937	1321
1948	113	295	1183	1591
1949	134	595	1789	2521
1950	123	595	2101	2822
1951	125	626	2912	3663
1952	135	510	2747	3392
1953	118	597	3288	4003
1954	118	545	2943	3606
1955	81	434	3235	3750
1956	110	419	3257	3786
1957	100	423	2678	3201
1958	82	350	2320	2752
1959	90	387	2395	2872
1960	98	393	2302	2793
1961	101	348	2201	2650
1962	118	316	2291	2725
1964	138	273	2345	2756
1965	155	289	2372	2816
1966	163	464	2368	2995
1967	180	408	2327	2915
1968	200	321	2575	3096
1969	192	335	2173	2700
1970	184	345	1929	2458
1971	140	283	1621	2044
1972	132	343	1777	2252
1973	108	345	1563	2016
1974	124	384	1735	2243
1975	103	326	1579	2008
1976	109	314	1610	2033
1977	114	317	1508	1939
1978	125	363	1367	1855
1979	120	391	1251	1762
1980	112	405	1200	1717
1981	114	445	1143	1702
1982	102	440	1261	1803

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1963 — C. A. LOVE, Retired Chief Mechanical Officer, Louisville & Nashville R.R., Louisville, Ky.

1964 — H. N. CHASTAIN, Retired Gen. Manager - Mechanical, A. T. & S. F. Ry., Chicago, Ill.

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1968 — G. F. BACHMAN, Retired Chief Mechanical Officer, Elgin Joliet & Eastern Ry., 612 E. Bevan Drive, Joliet, IL 60431

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We of the Chicago Railroad Diesel Club were again pleased to be hosts to the Locomotive Maintenance Officers Association for their April 4, 1983 Pre-Convention Presentation.

Meetings: We meet on the first Monday of each month except May, June, July, August and September.

Monthly Publication: Issued to all members.

Membership: We welcome all railroad and railroad supply personnel. For further details please contact our Secretary-Treasurer.

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Illinois Central Gulf Railroad Co.
6037 Aspen Lane
Matteson, IL 60443

Monday, September 19, 1983

10:00 A.M.

REPORT OF THE COMMITTEE ON NEW DEVELOPMENTS

Pre-Convention Presentation: Chicago Railroad Diesel Club

April 4, 1983 Midland Hotel Chicago, IL

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General Mechanical Engineer
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PERSONAL HISTORY

A. A. CHACON

A native of Illinois, Mr. Chacon lived in the small town of Dixon until he entered Illinois Institute of Technology in 1968. After graduating in 1972 with a Bachelor of Science Degree in Electrical Engineering, he went to work for Electro-Motive Division of General Motors as an Electrical Control Design Engineer.

In 1977, he left E. M. D. to begin his railroad career with the Union Pacific Railroad. After a short assignment in Omaha, Nebraska, he was transferred to Salt Lake City, Utah, where his responsibilities included the development of a training program for Mechanical Department mechanics. While in Salt Lake, he attended the University of Utah and received a Masters Degree in Engineering Administration.

In 1979, he was transferred back to Omaha as Assistant General Mechanical Engineer-Locomotives. In 1982, he was promoted to General Mechanical Engineer, the position he now holds.

He and his wife, Nancy, have a one-year-old daughter. In addition to the many things she finds for him to do around the house, he enjoys golf, snow skiing and scuba diving.

He is a member of LMOA, IEEE, ASME and the AAR Car Construction Committee.

MICROPROCESSORS FOR LOCOMOTIVE CONTROL AND SELF DIAGNOSIS

I. INTRODUCTION

"A large part of the rising affluence of the U.S. in the post-World War II years stemmed from the fact that the real prices of many of the U.S.'s most vital commodities declined, and often declined sharply — from gasoline to electric power to automobiles. They did so for a variety of reasons — technological change, the abundance of raw materials, multiplying economies of scale — but by the early seventies most of those forces had begun to run out. The next unit of almost everything costs more than the last, and when the price of oil lurched out of control in 1973, the game was over. Living standards began to decline.

But those dynamics of falling prices are still valid, and these days it is microelectronics that offers the best hope of getting those costs trending downward again — not from deflation, but from real productivity gains. The microprocessor has an insidious capacity for pervading every aspect of the economy — for filling it, reforming it and reshaping it to its image."*

The advances possible in locomotive availability, reduced maintenance costs and increased fuel efficiency through the use of the on-board microprocessor systems are a quantum jump from our present locomotive fleet capabilities. One example of the far reaching consequences of microprocessor ap-

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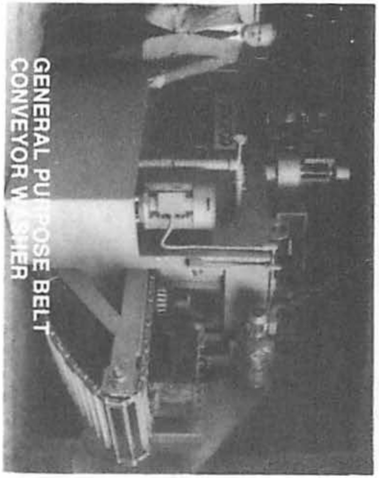

GENERAL PURPOSE BELT CONVEYOR WASHER

MINI TYPHOON 26-36 INSIDE A TYPHOON 60-72


TYPHOON TURNTABLE WASHER

plication are the improvements anticipated by the Bay Area Rapid Transit System of San Francisco. Their studies estimate that the planned introduction of triple redundant microprocessor based control and self-diagnostics to their rail transit cars will:

(a) increase control component reliability 300% (presently control system failures account for 20% of on-line failures).

(b) reduce control system component part number count 75%.

(c) increase the mean time between service disruptive failures caused by control system components by a factor of 20.

As a result of the above improvements in reliability and availability brought about by the introduction of on-board microprocessor control systems it is anticipated that the transit system will be able to double train density during peak rush hour operations without degrading service dependability.

Significant differences certainly exist between diesel electric locomotives and rail transit cars; however, there are strong parallels in the basic failure modes of the control circuitry and traction systems.

II. BACKGROUND REVIEW

Microprocessor, microcomputer, software — what is meant by these terms?

Microprocessor:

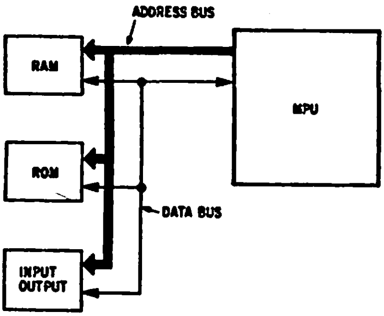
This is a portion of a microcomputer. It is a device that combines the central elements of the computer, its arithmetic, logic and memory registers on a single chip. It can be programmed with stored instructions so that this digital electronics package communicates with incoming data, and determines which information to store in memory and what resulting output action must be accomplished, if any.

Manufacture

1. Ingots are produced from pure silicon.
2. Wafers are cut from the ingots.
3. Layering process consists of oxide film, masking, etching, and diffusion is repeated several times.
4. Wafers are scribed and individual chips broken off.
5. Chips are mounted in protective casing and thin wire bonding conducted.
6. Chips are sealed, inspected and shipped.

Microcomputer:

A bus oriented digital computing network which is software controlled. A computer in the lowest range of size and speed. It consists of the memory, Input/Output interface, CPU (Central Processing Unit) and interconnecting bus. It accomplishes output functions based on programmed instructions for handling input signals.



Microcomputer system

Software:

The language and logic of the computer, where the language consists of words (fixed length binary number sets) accommodating data, addresses and instructions; with the logic being statement decisions of yes or no. It would specify which input data are to be stored, manipulated in calculations and which output response is to be conducted. For example, software would be the recipe that is inserted into the microprocessor system to explain how to compute horsepower as well as to signal an alarm condition when traction motor current short time limit is exceeded.

III.

LOCOMOTIVE DIAGNOSTIC SYSTEMS

A locomotive diagnostic system monitors the operation of mechanical components and electrical circuitry onboard the locomotive. This is accomplished by "tapping" the voltage signals in electrical circuits as well as using thermocouple, piezoelectric, and hall effect transducers to measure mechanical phenomena such as temperature, pressure and vibration. These data in turn are used passively to follow operations without affecting control and/or may actively interact with the control system to limit certain locomotive capabilities. The bottom line here being that the diagnostic system aid in increasing locomotive availability and decreasing manhour and material maintenance costs.

The microprocessor system can direct the storage of pertinent historical operation data, calculate performance such as horsepower output corrected for fuel temperature and ambient air temperature and pressure, as well as evaluate incremental changes and out-of-limit conditions. Through software changes the system has the flexibility of easy trend or limit modifications which require no hardware wiring or component change-out.

Harris Control Diagnostic System

One of the newest microprocessor based diagnostic systems was recently introduced by Harris Controls of Melbourne, Florida. Their system, called "PROBE," monitors, records and analyzes locomotive conditions for maintenance and train operation analysis. This system passively observes locomotive operations without interference to locomotive control. The system consists of 3 subsystems:

1. On-Board Diagnostic System.
2. Data Transfer Unit (DTU) used

to remove stored data from the locomotive.

3. Data Analysis Terminal, which receives data from the DTU which then is used to display and print performance reports concerning a unit's history.

The on-board system consists of an array of transducers/sensors which feed performance signals through buffer interface which "softens" the signal prior to transmittal to the microprocessor system (microcomputer). The microprocessor system stores selected data for later analysis at the data analysis terminal as well as comparing trends to program instruction limits and synchronizing data input such as the power assembly monitoring functions. Based on these inputs this electronic package in turn will send signals to the annunciator panel which will indicate fault as well as present status conditions.

The on-board portion of the PROBE system consists of:

— An electronics module

— A display panel

— Transducers

The system measures various parameters via the transducers and signal isolators. The performance parameters are compared with the limits for the current operating mode. If the limits are exceeded and if several other conditions are met, an indicator on the display panel is illuminated and data are stored in the non-volatile memory. This data is called a Fault Record.

The operating parameters are compared with their previous values. If the operating conditions have changed significantly, an Operating Record is stored in the non-volatile memory.

Periodically, averaged performance data are stored in memory. This is called a Trend Record.

The basic system monitors fuel consumption, ambient conditions, and portions of the electrical control system.

Some of the add-on options available are:

1. Individual power assembly combustion chamber pressure vs. time monitoring.
2. Turbocharger vibration.
3. Electrical control loop — throttle response, load regulator, and sensor loop.
4. Traction motor currents and support bearing temperatures.
5. Air compressor lube oil temperature and pressure.

For example, the power assembly combustion chambers are monitored by eight load cells. These load cells are power assembly crabs with imbedded piezoelectric crystals which send output signals proportional to the pressure in the power assembly. Since one crab is used to monitor two adjacent power assemblies the firing sequence must be synchronized by a signal from the crank angle sensing device mounting on the ring gear. The crank case pressure and the pressure vs. time curve are checked for compression and firing response at idle so as to notice performance degradation that would

be the result of cylinder scoring, excessive ring wear, burnt exhaust valves, etc.

The purpose of the Data Analysis System is to input, store and analyze data acquired from the probe on-board Monitoring System. The Data Analysis System's man-machine interface is user-oriented. System control is accomplished through operator selection of a command from a menu on the CRT screen.

The system is configured to display data associated with locomotive performance and train operations.

Some of the reports available are:

1. Diagnostic data
2. Performance Summary
3. Fault analysis and limits
4. Operation summary, analysis and limits

For example. the fault analysis system provides output pertinent to the reconstruction of the conditions which existed during a fault. The data are derived from the fault data file. These data are available from the latest period only.

The following quantities are included in a fault analysis report:

a. Data/Time of Fault(s)
b. Mode of Operation
c. Alarm Condition(s)
d. Fault Condition(s)
e. Analog Values; including:
   — Traction Motor Currents
   — Power Assembly Factors
   — Engine RPM
   — Main Generator Output
   — Fuel Flow Rate

General Electric Diagnostic System

The introduction of the microprocessor system to the General Electric Dash 8 locomotive both dictates the need for and allows the introduction of on-board diagnostics. As improved reliability is a key objective of the Dash 8, an on-board diagnostics will contribute to this improvement, the diagnostic system must have extremely high reliability.

To meet this objective, sensors have been limited to those that are proven in locomotive service. As micro-computers provide the diagnostic capability, diagnostic inputs are primarily electrical signals from control and propulsion systems. Temperature inputs are limited to ambient, water, and oil. State of all power switching devices is measured with a two-position sensor. Inputs of locomotive, motor and turbo speeds are provided. The inputs selected are highly reliable and permit accurate monitoring of total locomotive systems.

Diagnostic system outputs are provided on an alpha-numeric vacuum fluorescence display located in the locomotive cab. Up to two lines of 40 to 80 characters will be used. Outputs will include both numerical code and word messages.

EMD Diagnostic System

1. The diagnostic system equipment will be incorporated into the hardware package containing the logic and excitation control equipment. This will provide a self contained system on board each loco-

motive, thereby making connections to external computers or display units unnecessary.

2. A multi-function display will be incorporated to provide diagnostics information, in English text, to locomotive Engineers and Maintenance personnel. The display will replace the present arrangement or status indicator lights on the engine control panel and fault condition indicators on the annunciator module. Additional information which can be displayed include:

a. A history of abnormal conditions which have occurred during a trip or since the previous locomotive inspection.
b. Load test information such as volts, amperes and horsepower.
c. Information to assist in fault tracing.
d. Specific components determined to be faulty by the diagnostics system.

3. An output connector may be provided to interface the locomotive to an external device such as a printer or remote video display.

4. Self test features will check the operation of Electro-Mechanical devices as well as the electronics.

5. Input/output status indicators will display the control sequencing of the logic relay functions which have been replaced by the microprocessor.

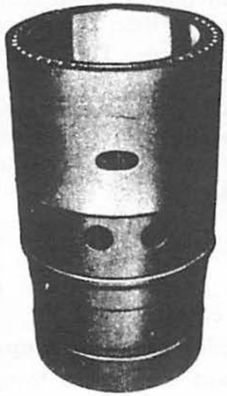
6. The design of the diagnostics system will first maximize the information available from the transducers presently applied to the locomotive. New transducers will be added as the need for new diagnostics functions arises.

IV.

LOCOMOTIVE CONTROL

One may roughly say that electrical control has historically evolved from relay logic, to vacuum tubes, to transistors, to integrated circuitry till presently the use of the microprocessor based systems. The design of the electrical control circuitry of today's freight locomotive fleet remains at the infancy of these technological developments. Miles of interlock wiring, stacks of electromechanical relays, as well as rows of transistors, diodes and resistors fill locomotive electrical cabinets. One loose wire, one faulty interlock and the locomotive may go bottoms up, perhaps flashing a traction motor or power contactor with it. Then where is the problem? — at times its like searching for a needle in a haystack.

Microprocessor systems have the ability to solve complex problems rapidly and reliably. The precise timing of these systems assures exact sequencing of control interlocks and contactors with no inherent "age" drifting that occurs in present set points as in time delay relays. They provide for system growth in terms of communications, interconnectors and control complexity. The quality of locomotive operations can be maintained more precisely, such that the loco-



motive can be assured of operating nearer the initial design intention rather than varying haphazardly between 100-300 horsepower.

Prior to the use of microprocessors in industrial applications such as the automobile industry, automakers hard-wired thousands of relays into complex electromechanical systems that controlled the production lines. Model changeovers required scrapping the old system and designing, building, wiring and maintaining a completely new system with each annual model change. With changeover to microprocessor control, new instructions are programmed or written into the internal memory. Likewise for locomotive control, changing derating characteristics, minimum continuous speed points, and modifications such as low idle would require only a programming change with no component or wiring modification.

GE Dash 8 Locomotive

With the microprocessor system or microcomputer, many things are possible over and above the normal control functions available on current locomotives.

Reduced auxiliary power requirements tie directly to improved efficiency. The microprocessor system provides the control logic to accurately match auxiliary horsepower to equipment cooling requirements for varying operating conditions. For example, the radiator fan system utilizes two variable speed fans. Each is driven by an AC motor and controlled by a solid state three-speed controller. Each fan motor is controlled as a function of engine water temperature. The fan's ability to run at 0, 25, 50 or 100 percent of engine speed produces almost infinitely variable control. The control logic is such that one fan operates at 1/4 speed followed by 1/4 speed on the second fan — alternating up to full fan speed or until sufficient cooling flow has been achieved. The reverse logic is applied when cooling requirements are reduced.

The best technique in control is to always have a feedback at every step and on all elements in the system to be sure that the expected performance is actually occurring. With feedback from each device and subsystem, the system can make those adjustments necessary for proper functioning when something happens a little sooner or later than planned. The central computer can keep things flowing smoothly insuring that events occur in the proper sequence. For example, it is important when going from power to dynamic braking to know that:

— Power really goes down.

—Traction contactors — all of them — open.

— The braking control sets up.

It is important that these things happen and in that order every time. The computer provides the capacity to process the magnitude of data involved in total system monitoring.

Having information on the status of all elements within the control,

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NATIONAL DE-7 brushes. For superior commutation, long service life and low electrical maintenance. They're ideal in locomotive traction motors, transit and off-highway equipment. Available in two- or three-wafer styles. So you know we can meet your needs. NATIONAL DE-7 brushes. You can depend on them . . . worldwide.

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opens a whole new world in reliability. The central computer will be programmed to exercise the total control system whenever confirmation of the locomotive status is desired. Because the computer is so fast, interrogation is not limited to simple tests — the whole electrical control system can be tested.

Automatic self-test is not limited to being a powerful maintenance tool. With the locomotive in actual service, these self-test routines will automatically be initiated when trouble occurs. The computer is programmed to recognize problems and work around them whenever possible. For example, if one radiator fan cannot run at full speed, the computer will direct it to run at whatever speed it can and call for the other fan to make up the difference; This strategy will result in requested power being available except at high ambient temperatures. Even then, the locomotive will not shut down but will respond to the computer's directions to proportionally reduce power. In other words, the system will "fail soft" thus minimizing locomotive shutdowns and extended road delays.

To enhance the basic diagnostic value the microprocessor system offers, and to further reduce out-of-service time, all of the control equipment is packaged into replaceable units, RU. These units are designed for quick changeout. The diagnostic display spells out the specific replaceable unit that has failed. Maintenance loosens four bolts, unplugs the connections and slides out the RU, replaces the RU, plugs it in and tightens the bolts. This quick changeout is the extent of the trouble shooting and repair necessary before the locomotive can be self-tested and returned to service.

V. SUMMARY

We are at the threshold of a new era in locomotive design, one in which on-board microprocessor systems hold great promise for reducing locomotive capital and operating costs. The potentialities for increasing locomotive availability as well as increasing fuel savings by better controlling the overall quality of locomotive performance are most exciting.

The railroad industry has seen many changes occur in the last several decades; changes such as the transition from steam to diesel locomotives and manual record keeping to main frame computer data files. Let us now move forward towards this next transition.

Through a prudent incorporation of the microprocessor on board the locomotive this equipment can be made extremely reliable in itself. By minimizing the initial number of add-on transducers and requiring redundancy in the control design, we will win the confidence of the maintenance personnel who utilize this equipment and assure its success.

Locomotive Fuel Tank Gauges

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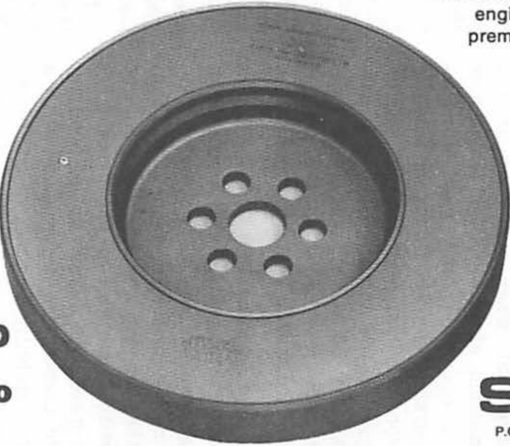

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P.O. Box 28646 • Memphis, TN 38128 • Phone (901) 372-6440 addressing one of the joint meetings, the president of one of the major railroads threw out a challenge to our membership and to our suppliers to develop improvements in locomotives that would increase their reliability and insure their compatibility with each other. One of the things he suggested was an improved fuel gauge that would be at least as accurate as the one on his Ford Falcon.

The need for reliable fuel gauges that are easy to maintain becomes apparent when we consider the number of run-through trains now in operation, the need for accurately determining fuel actually consumed on each railroad taking part in the operation, and the possibility of state taxation of locomotive fuel based on the amount burned within a state's boundaries.

In December 1981, the AAR sent letters to suppliers of liquid level gauges and to the two major locomotive builders requesting that they develop a gauge that would be within one half of one percent accurate with a track out of level not to exceed two degrees and with a repeatability accuracy of one fourth of one percent of the total fuel capacity. AAR also requested that the system be designed to be retrofittable to existing locomotives without removing the tank or without welding on the tank. None of the present production gauges meets those AAR specifications.

Some who received the letter elected not to pursue it. But three or four of the major companies including those presently making locomotive gauges are actively working on a gauge to meet the AAR specifications. One of those companies presently making a float-type gauge has developed a new one they believe will perform within an incremental accuracy or repeatability of plus or minus 25 gallons or plus or minus 1/2 percent in tanks of 3,500 to 4,000 gallon capacity.

This reliability was achieved by constructing the gauge with better and stronger materials in all of the critical places. The float rod was changed from aluminum to stainless steel, the gears and bearings are hard nickel plated, the center shaft has been changed from aluminum to stainless steel and all other wear or damage areas were changed or beefed up. All of these changes are incorporated into a gauge that physically appears very similar to standard gauges now in use but is considerably more rugged and can be expected to outlast the standard unit.

New seals were developed for the dial chamber, which should eliminate the problem of fuel oil leaking into this part of the gauge. A larger and stronger magnet on the pointer was added to permit a much larger indicator. The crystal can be replaced without changing the entire dial unit, as was necessary with previous models. One of the most desirable features of this new gauge is its ability to be converted for remote reading by simply replacing the standard dial chamber with a remote reading dial

chamber and associated receiver. Twenty of these gauges are being tested on UP locomotives.

It is not necessary to drain the tank to install this new gauge, and it will fit on the same mounting pad. It can be top mounted or side mounted on request.

Another type of gauge now being tested is a fuel level manometer, which is similar in appearance to some of the present fuel level gauge glasses now in use, this manometer uses a freeze-proof indicating fluid in a heavy-duty capillary tube gauge glass instead of the fuel oil used in the previous gauge glass types. This eliminates the problem of dirt and varnish deposits on the glass, which made readings illegible and required frequent cleaning. The gauge block mounts permanently, has no moving parts, and never needs replacement parts under normal operating conditions. No welding is required with this installation, all components can be renewed without draining the fuel tank, and the gauge is designed to retrofit existing fuel tanks. It measures in 100 gallon increments and claims an accuracy to ± 1 percent. No provisions are made with this type for temperature compensataion or for track cross level.

Up to the present mechanical float or glass tube gauges have proven unsatisfactory. Although not yet available, solid state devices that utilize the capacitance measuring principle or pressure transducers and one or two probes to monitor the liquid level are being developed. These probes have a radio signal induced onto them; the signal measures the capacitance or pressure of the level of the fuel in the tank. This signal is then transmitted to a gauge in the cab or any other location on the locomotive desired by the carrier.

Many variations and functions could be monitored with this type of system, including the capability to produce a printed card by plugging in a portable device to a receptacle mounted on the locomotive and the production of a digital readout in the cab. It could be hooked to a relay connected to the train line wiring to operate a warning light should the fuel level reach a prescribed low limit. It could provide temperature compensation so that each reading would take temperature into consideration. This is desirable since variations will run about 1 percent for each 20 degrees of temperature variation. Finally, it could be programmed to measure total usage over a prescribed period of time.

Each of the optional systems would naturally increase the cost of the package. Since such packages are not yet in production, prices have not been established; but it is estimated that the basic gauge would cost about $600 and could run to several thousand dollars for one with all the options. The least expensive system would employ a (picometer) portable device to be connected to a receptacle on the locomotive at each location where a reading was desired and

would require a separate conversion chart for each locomotive, or group of locomotives, to convert picofarads from the radio signal to gallons. No direct readings would be made on the locomotive.

It is likely that some welding will be necessary to install the probes into the tanks. Probes will in most cases be top mounted with one directly in the center of the tank or two mounted in opposite corners. This would be necessary to read either the center of the tank or each corner and calculate an average of the two so that cross level of the track is taken into consideration. It is expected that before our convention this fall, prototype gauges using solid state principles will be on test from at least a couple of vendors.

Locomotive Aerodynamics

Electro-Motive has an active development program on locomotive aerodynamics with the primary objective of achieving fuel savings.

Considerable testing already has been conducted using 1/8 scale model GP locomotives at GM's new wind tunnel facility at the Tech Center in Warren, Michigan. Both basic and modified locomotive configurations in single and multiple unit consists were tested. The models also had air flow from the locomotive roof to simulate engine exhaust and cooling fan discharge air.

The chart indicates the basic finding that at 60 MPH, 225 HP is required just to overcome wind resistance on the lead locomotive. The horsepower required increases with speed squared, thus higher speeds are a most important factor in fuel economy.

Modified configurations have resulted in a 75-100 HP reduction at 60 MPH which amounts to the following fuel savings.

3% on single locomotive
1% on 3 unit consist
.75% on 4 unit consist

As indicated by the reduction in fuel savings when in multiple unit operation, the big advantage exists only on the lead locomotive.

Further wind tunnel testing is planned to determine the most practical methods to achieve improved aerodynamics. An objective of these 'practical methods' is that they do not require any added maintenance nor detract from locomotive reliability.

Since the improved configuration has not been finalized, no comments concerning retrofit can be made at this time.

Bombardier HR 616 Locomotive

We are in an era in which revolutionary ideas and changes are taking place in locomotive design. Perhaps one of the most interesting changes is in the HR616 locomotives dubbed "Draper Taper" by Bombardier, builder of the first 20 units. It's in large measure the brainchild of William L. Draper, Assistant Chief of Motive Power Operation Department of the Canadian National Railroad. These units are a 3200 horsepower, 6-axle road locomotive, originally ordered by CN in July 1980.

Some of the design changes resulted from a need for improved safety, performance and reliability for operation in a northern climate, where snow and ice become not only an operational problem but also one of safety and maintenance. Technicians from both CN and the builder worked together to bring about some of these design changes.

CN experienced a severe winter in which traction motor failures, because of moisture, increased from a norm of 50 per month to 250 per month. This, coupled with a spectacular derailment and subsequent fire in a Toronto suburb, pointed to a need for better train inspection from the locomotive cab. Those two problems and several others were attacked by William L. Draper, who has many years of experience in wintertime operation of diesel locomotives.

Draper set up a small research operation near Stanford, Ontario. The idea was to find out the exact mechanics by which excessive snow enters the traction motor cooling system and causes premature failure of the traction motor because of moisture. This was accomplished by the use of TV cameras and personal observations.

Briefly, the solution was to install air ducts to each motor from a central blower housing located at the forward end of each locomotive. The blower housing has a system or louvers in the top, Servo-control. The Servo will be activated by the change in the traction motor temperature. When the temperature rises, the louvers will open to emit air.

It is expected that during winter weather, the louvers will remain closed much of the time, largely eliminating the problem of snow shorting out the traction motor. It should be noted that with changes in the carbody configuration, "Draper Taper" allowed for extra space in the duct system allowing the cool air to be brought in from the top of the locomotive, rather than from the sides. This means that by using top entry for the cooling air, far less snow is induced into the system. With the use of top entry system and the louvers controlling the air to the traction motor, 80 percent of the snow will be eliminated in the air cooling system to the traction motor.

An additional benefit this system affords is that when the louvers are closed, the load on the blower is reduced. In effect it is "feathered." In this mode the horsepower drawn from the main engine at full load is reduced from approximately 120 horsepower to 20 horsepower. In sustained operation this will mean significant fuel savings.

The HR616 is a mainline freight unit with a wide carbody. But it features a revolutionary cut away behind the cab. A 14-inch covered walk way space was designed, extending to the rear at a gradual decreasing width or tapers, "Draper Taper," which allows the Engineer exceptional rear visibility for a wide carbody. This also allows full view inspection of the train, even on a slight curve.

A narrow body design makes engine maintenance difficult in the winter. At times snow would completely block access to the engine compartment and the catwalk along the side of the locomotive. The catwalk would frequently jam with snow and create a hazard for crews. CN tested grating for catwalks, but that provided little relief from snow build up. The widebody design eliminated catwalks and made routine maintenance much easier. Access to the prime mover is internal through a door between the cab and the engine room. However, the traditional side access doors on locomotives have been retained.

The cab is considerably larger than road switchers. The electric cabinet has been moved back, thus increasing cab floor space by about 20 percent. Also, later models will have a new and bigger console. Elimination of the present controller will create additional free space in the cab.

The merits of this new design are many. For safety, the visibility to the rear is comparable to a narrowbody locomotive. This is attained by the fourteen foot taper immediately behind the crew compartment, while still retaining the advantages of the wide car body, namely, superior aerodynamics and access to the engine compartment from the control cab for safe enroute inspections and repair.

Maintenance

Shop repairs are aided by hinged roof flaps for cylinder removal, while side doors of the narrow carbody type are retained. Elimination of hand rails is also an asset to maintenance. Of course, the substantial reduction of traction motor failures during winter operation will lead to significant reductions in repair and replacement costs.

Economy

A 7 percent saving in fuel consumption is expected during winter operations. This is due primarily to blower shutdown and redesigned power assemblies. Another feature of this new locomotive is Bombardier's new wheel-slip control that represents great improvement in adhesion at midrange speeds over previous state-of-the-art systems.

In conclusion, CN and Bombardier are to be commended for their collaboration in the design and production of this outstanding locomotive.

Missouri Pacific — Phase III Locomotive Heavy Repair Facility North Little Rock, Arkansas

The Missouri Pacific's Pike Ave. Shops in North Little Rock, Arkansas were originally constructed in 1904 for the purpose of building, rebuilding, and repairing steam locomotives, passenger cars, and freight cars. Eventually, the passenger and freight car work was transferred to other system shops. By 1956 dieselization was complete on the Missouri Pacific, and the facilities at Pike Avenue were adapted to perform diesel locomotive servicing, running repair, and heavy repair. In addition, the Pike Avenue facility reworked the com-

ponents required to support those operations, as well as to supply the needs of the rest of the system.

In 1964 the centralized system wheel and air brake shops were constructed at Pike Avenue. In the period from 1968 to 1971, locomotive servicing and running repairs were moved to new facilities located in the train yard several miles away. The new service facility is known as Phase I and the new running repair facility is known as Phase II.

As the locomotive fleet has grown over the last 20 years through mergers and new unit acquisitions, it became apparent that the Pike Avenue facility would soon be unable to meet the required output. Even by increasing the work force on the second and third shifts, the existing Pike Avenue shop would be unable to cope with the growing locomotive fleet by the early 1990's. In addition, the movement of locomotives and components through the shop would become increasingly cumbersome, locomotive out of service time would become excessive, and work methods would remain inefficient.

The existing buildings, now over 75 years old, would need millions of dollars worth of repair and modification to keep them operating into the early 1990's. Despite the expenditures required, there would be no improvement in the ultimate shop capacity, nor improvement in shop efficiency. In addition, while the rehabilitation programs were being implemented, shop production would be greatly impaired. Finally, in the early 1990's, the Missouri Pacific would still be faced with the necessity to build an entirely new shop estimated to cost three times present day costs.

In the latter part of 1980, MoPac management decided to design a new diesel shop complex in North Little Rock to be known as the Phase III Locomotive Heavy Repair Facility.

In November 1981 the design team was assembled in St. Louis, and a meeting held to discuss the Phase III Shop Project. The design team had a unique opportunity: having an essentially "blank piece of paper" on which to design a new diesel locomotive repair facility to serve MoPac for many years.

During the first meeting, an outline for discussion was presented, consisting of:

1. The scope of work to be performed at the new facility;
2. The different departments or work areas required to support the work to be done;
3. The size of the new shop;
4. Special equipment and machines or special shop features that would have a major effect on shop efficiency or configuration.

Each category was discussed, and it became apparent that designing a facility as large and complex as Phase III would be a formidable challenge.

The scope of work to be performed at the new facility includes:

1. Double truck change;
2. Accident repair, both light and heavy;
3. Power assembly change;
4. Locomotive rewire, both partial and complete;
5. Locomotive heavy overhaul;
6. Locomotive remanufacture or program heavy modification;
7. Locomotive painting;
8. Miscellaneous locomotive repairs.

Different types of work areas to support the kinds of work performed are detailed in Figure 1. See Page 136.

The categories are:

1. Locomotive work areas;
2. Component work areas and fabrication areas;
3. Storage areas;
4. Shop support and maintenance areas;
5. Administration, training, and personnel areas.

The size of the shop is controlled by several factors. The track space provided in each work area is determined as follows: In those areas where locomotive work is to be performed in a single spot, the number of spots will be determined by the volume of locomotives to be handled in a given time period. For those areas where locomotive work is to be performed on a progression basis, the number of spots will be determined by the types of operations being performed and the time allotted to that operation.

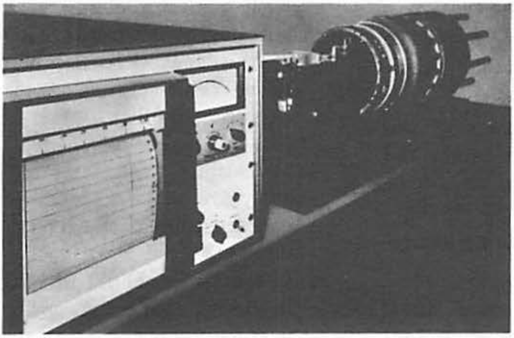
The space allotted to component rework will be determined by the following: First, the required output volume to supply both the Phase III shop and other system shop requirements; second, the physical space requirements of machinery and operating area; and third, the volume of in-process material and repair parts to be kept in the work area.

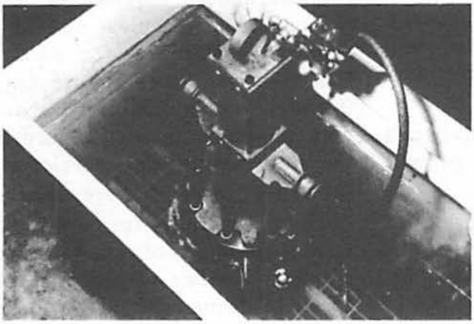
The space allotted for the storage of material in the shop will be determined by the following factors: First, equipment that is too large or too heavy to be moved to the system storehouse. Second, material that is reworked or fabricated in the shop that will be shortly used in one of the locomotive work areas. Third, materials such as bolts, nuts, gaskets, wire, etc. used continuously in various shop areas and would cause delays if the material could not be delivered promptly. In many cases, the exact quantity or type of material is not known beforehand.

Another factor that will affect the space allotted for storage is the availability of outside storage areas for some types of material, provided an efficient means of handling the material is provided.

Another consideration was special equipment machines, or special shop design features that will affect the layout or configuration of the new facility. This includes, but is not limited to, the following:

1. The use of transfer tables instead of track switches;
2. The use of a rubber tired car mover to move locomotives;
3. The use of a 250-ton overhead crane to perform double truck changes in lieu of a single truck drop table;





4. The capacity, span, and configuration of large overhead cranes;
5. The use of smaller gantry-type and underhung cranes in component rework and fabrication areas;
6. The use of between the rail pits, tracks on pedestals and elevated platforms to facilitate certain types of work;
7. The types of cleaning equipment to be used.

Decisions about these and other types of equipment and shop features would have a great effect on the development of the shop design.

Decisions were made at the initial meeting that set several guidelines for the design process. They were as follows:

1. An initial project budget range was established.
2. The design of the shop should include facilities that will yield yearly operating savings of 12-20 percent.
3. The shop should be designed for approximately 67 percent utilization.
4. The shop should be designed to be in full compliance with OSHA and EPA regulations.
5. The design capacities should consider the transfer of certain types of work from other system shops to the new shop and the possibility of transfer of some types of work to the Union Pacific shops in Omaha if the proposed merger is approved.
6. The design should be adaptable to changing locomotive and component requirements with minimum changes to the building structure or services.
7. If the new shop complex is to be relatively close to the existing facility, then care must be taken to insure that operations at the existing facility are not disrupted during construction of the new facility.
8. Locomotives should be cleaned in designated areas prior to performing other work. Cleaning of equipment, components, etc. shall be of prime importance.
9. Locomotives are not to be run within the main building.

Once the scope of the project had been determined, a study plan was prepared to systematically develop the information required to design the new shop complex, and to put together a proposal for construction approval. (See Figure 2) An initial schedule was set up along with the study plan to assure that the information was developed in the proper sequence. See Page 136.

Then, several trips were made to visit the shops of other railroads. A large number of pictures were taken to document what was seen, and a great deal of information was obtained. A number of ideas thus obtained were incorporated into the shop design.

Much of the information concerning the present and projected requirements for the numbers of locomotives to be serviced, com-

ponents to be reworked or fabricated, the amounts of material to be kept on hand, and the required work force, was obtained by careful evaluation of production records, shop force records, and careful observation of the existing shop operation. A comprehensive list of questions was prepared and the answers were obtained through close contact with the Pike Avenue Shop management. Many of the projected requirements were determined by using a projected locomotive fleet size established by the superintendent of motive power, and applying a scheduled maintenance criteria for different components such as trucks, power assemblies, diesel engines, etc.

The next step was to evaluate different methods of material and locomotive movement within the shop. With respect to material movement, careful attention was given to the system of overhead bridge cranes. Crane capacities were made sufficiently high to handle any conceivable lifting requirement that would occur within any given area of the shop. The minimum capacity of the large cranes was set at 15 tons.

For individual work areas, the lighter lifting requirements would be handled with single-leg gantry cranes and underhung cranes. A decision was made to avoid the use of jib cranes if possible because of their limited capacity and coverage. The control of cranes is another important area for evaluation. The larger top running cranes would be radio controlled, and the smaller gantry and underhung cranes would be pendant controlled. In each case the cranes would be operated by whichever craft required the use of the crane, thereby eliminating the requirement for a designated operator in the crane. Careful evaluation was to be made as to the number of cranes to be used, and to the coverage area of each crane, as the resulting crane system would have a profound effect on the overall efficiency of the shop.

With respect to the movement of material by forklift, the decision was made to minimize this requirement within the shop, particularly within component areas. Careful attention was paid to the system of aisleways within the shop. Main aisleways were to be of sufficient width to allow two forklifts to pass with ample clearance. The system of aisleways was laid out to provide a loop pattern for material deliveries, with designated material drop-off locations. Storage areas within the shop would be of sufficient size and strategically located so as to minimize the movement of material during heavy shift operations.

With respect to the movement of locomotives, the earlier decision to prohibit the running of locomotives within the shop led to the decision to use a rubber tired car mover, also to be equipped with hi-rail. Several other key decisions were made at this point with respect to the movement of locomotives. A thorough evaluation showed that the use of a 250-ton overhead crane in lieu of a single truck drop table

would provide a cost effective method of performing double truck changes both in initial capitol expense, and in the time savings. The 250-ton crane also would be of value in the general movement of locomotives within the crane bay and would especially be of use handling locomotives in the accident repair area. The use of the 250-ton crane had a major effect on the final configuration of the shop.

Another decision that had a major impact on the layout of the overall facility was the decision to use transfer tables to access the shop instead of track switches. This allowed the facility to be laid out in a compact and efficient form, and when combined with the use of the rubber tired car mover, would eliminate the need for live locomotives and hostlers.

Using the information obtained earlier in the study, approximate areas were developed for each component rework or fabrication area. When combined with the decisions made with respect to the movement of material and locomotives, several possible configurations for the shop and overall facility layout were developed for discussion and evaluation.

Many hours of discussion and evaluation led to the adoption of a layout proposal that became the basis for the final design proposal.

The next area of development was the layout of each of the locomotive work areas and component areas. It was in this phase that the information gathered in the earlier shop visits proved to be of great value, particularly in the selection of special equipment, fixturing, and work methods.

Work flow diagrams were developed for each area, which were valuable tools in the layout of each area. As the layouts progressed, the allotted space for each work area was adjusted as necessary. It is important to point out that throughout the design process, special attention was paid to keeping the layouts as adaptable as possible, to allow changes, and additions without having to modify the building structure or utilities. In keeping with this policy, the use of pits and utility stub-ups in the floor were minimized. Another important point to be made is that throughout this phase of the design process, close contact was kept with the Pike Avenue Shop personnel. The input of all of the shop personnel was considered very important.

Heavy equipment requirements also were developed at this time and inquiries were made with manufacturers to develop estimates to be used for the total facility cost estimate.

At this point in the development of the design proposal, a 1/87 scale model was constructed. The model proved to be a valuable tool, not only as part of the proposal for construction approval, but also in further refinement of the shop design. The model was transported to the existing shop in North Little Rock. All employees were shown the model and the proposed operation of the shop was explained. Comments regarding the design and operation were noted and encouraged. Several comments resulted in changes in the shop design.

It was at this point that the proposal package was presented to management for approval. Once approved, the project moved into the next phase.

Owing to the size and complexity of the project, the decision was made to hire an architectural engineering firm to turn the Missouri Pacific designs into a complete construction package. The firm of Ellerbe, Inc., located in Bloomington, Minnesota, was selected to complete the design package. Missouri Pacific personnel worked closely with Ellerbe's architects and engineers in the development of the construction package. Throughout the process, the design was revised and refined several times, until finally it evolved into the layout as shown in Figures 3 and 4.

Although the shop is well along in construction, the design process has not ended. Small changes are still being made and shop work areas are still being refined. The process will probably still be going on even after the shop goes into operation.

LOCOMOTIVE HEAVY REPAIR FACILITY GROUND FLOOR AND MEZZANINE PLAN

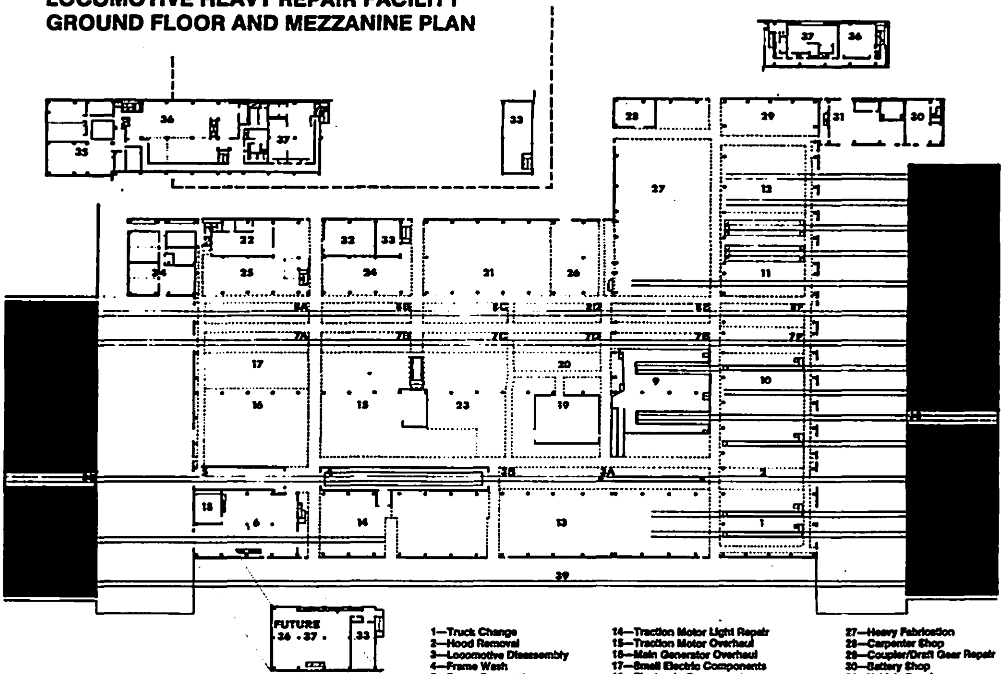
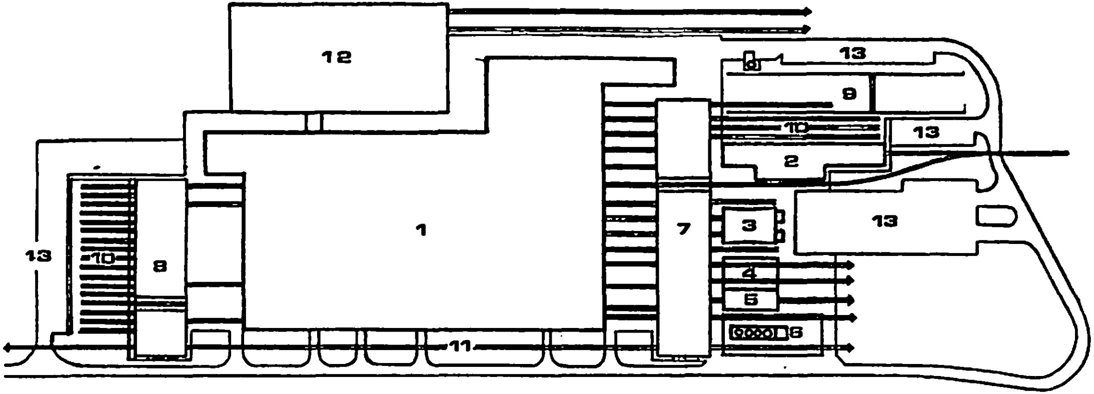


FIGURE 3

LOCOMOTIVE HEAVY REPAIR FACILITY GROUND FLOOR AND MEZZANINE PLAN

1—Truck Change
2—Hood Removal
3—Locomotive Disassembly
4—Frame Wash
5—Frame Preparation
6—Rewire
7—Locomotive Rebuild
8—Locomotive Remanufacture
9—Strip Job
10—Miscellaneous Repair
11—Light Accident Repair
12—Heavy Accident Repair
13—Truck Rebuild
14—Traction Motor Light Repair
15—Traction Motor Overhaul
16—Main Generator Overhaul
17—Small Electric Components
18—Electronic Components
19—Engine Disassembly
20—Small Engine Components
21—Power Assembly Overhaul
22—Injectors/Governors/Speed Recorders
23—Engine Rebuild
24—Air Compressor Overhaul
25—Machine Shop
26—Light Fabrication
27—Heavy Fabrication
28—Carpenter Shop
29—Coupler/Draft Gear Repair
30—Battery Shop
31—Vehicle Repair
32—Building Mechanical
33—Building Electrical
34—Training Center
35—Administration
36—Lunch Room
37—Locker Rooms
38—Transfer Table
39—Runaround Track



PHASE III LOCOMOTIVE HEAVY REPAIR FACILITY

AREA LAYOUT

1. MAIN SHOP BUILDING
2. PAINT BUILDING
3. LOAD TEST BUILDING
4. SHUTDOWN / START UP AREA
5. PREWASH BUILDING
6. TANK FARM & PUMP BUILDING
7. NORTH TRANSFER TABLE
8. SOUTH TRANSFER TABLE
9. OUTSIDE STORAGE AREA
10. LOCOMOTIVE STORAGE TRACKS
11. RUN AROUND TRACK
12. EXISTING MATERIAL DISTRIBUTION CENTER
13. PARKING AREAS

FIGURE 4

Figure 1

Locomotive Work Areas

1. Truck change area.
2. Accident repair area.
3. Strip job area (power assembly change).
4. Miscellaneous repair area.
5. Rewire area.
6. Heavy overhaul tracks.
7. Remanufacture or program heavy modification track.
8. Locomotive wash areas.
9. Load test facility.
10. Paint facility.
11. Shutdown/startup areas.

Component Work Areas And Fabrication Areas

1. Coupler/draftgear repair.
2. Heavy fabrication (metal working, pipe).
3. Light fabrication (sheetmetal, coolers).
4. Power assembly rebuild.
5. Air compressor rebuild.
6. Injector/governor/speed recorder rebuild.
7. Machine shop.
8. Small mechanical component rebuild.
9. Diesel engine rebuild.
10. Small electrical component rebuild.
11. Traction motor/main generator rebuild.
12. Truck shop.
13. Traction motor light repair.
14. Electrical cabinet rewire area.
15. Electronic component shop.
16. Battery shop.

Storage Areas

1. Tool storage areas.
2. Maintenance material storage.
3. Diesel material storage.
4. Outside storage—locomotives.
5. Outside storage—material.

Shop Support and Maintenance Areas

1. Shop vehicle repair.
2. Building mechanical areas.
   A. Compressed air systems.
   B. Water systems.
   C. Emergency lighting generators.
3. Building electrical distribution areas.
4. Storage tanks and pumping equipment.

Administration, Training And Personnel Areas

1. Shop Superintendent's office.
2. General office area.
3. Conference rooms.
4. Shop engineer's office.
5. General foreman's offices.
6. Training rooms.
7. Instructor's office.
8. File storage.
9. Lunchrooms.
10. Locker rooms.
11. Restroom facilities.

Figure 2

PLAN OF STUDY

1. Establish a series of shop visits to other railroads.
2. Determine the physical dimensions of possible site locations and show on existing area drawings.
3. Determine the present and projected numbers of locomotives to be serviced in each area on a daily or weekly basis.
4. Determine the present and projected numbers of components to be repaired, reworked or

fabricated in each area on a daily or weekly basis.

5. Establish the amounts of new and rebuilt material to be kept on hand in the shop.
6. Determine the present and forecasted work force for the shop on a daily and shift basis, and establish a probable male/female ratio.
7. Determine methods of material and locomotive movement in the shop.
8. Determine, using items 3 thru 7 and additional observation, the approximate areas required for each work area.
9. Establish several basic shop layouts and work/material flow diagrams for several shop locations, along with possible track configurations.
10. Through discussion, determine the best possible layout and location for the new shop.
11. Develop work flow diagrams for each work area for the optimum layout of work areas.
12. Determine heavy equipment and crane requirements and make initial inquiries for cost estimates for the manufacturers.
13. Develop a floor plan for each work area.
14. Integrate the individual areas into a final plan proposal for submission to the architects' office for a total cost estimate.
15. Develop a track plan for optimum movement of locomotives.
16. Construct a scale model of the proposed shop layout.
17. Integrate the layout plans, written proposals and justifications, and the scale model into a complete proposal package.

COMMITTEE ON DIESEL MECHANICAL MAINTENANCE

PRE-CONVENTION PRESENTATION, KANSAS CITY

GOLD BUFFET RESTAURANT, APRIL 12, 1983

Railroaders and supplymen were pleased to be hosts to the Locomotive Maintenance Officers Association Committee on Diesel Mechanical Maintenance for their Pre-convention presentation at Kansas City on April 12, 1983.

Our thanks to Mr. T. D. Mason, and his staff, for their effort in making the presentation a success.

Monday, September 19, 1983

2:00 P.M.

REPORT OF THE COMMITTEE ON DIESEL MECHANICAL MAINTENANCE

Pre-Convention Presentation: Santa Fe Railway Kansas City, MO

April 12, 1983 Gold Buffet Kansas City, MO

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Superintendent Motive Power
Burlington Northern Railroad
St. Paul, MN 55101

VICE CHAIRMAN
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T. G. Winfield	Asst. Mgr. Tech. Service	EMD	LaGrange, IL

1983 TOPIC;

"COST CONTROL AND EXTENDED SERVICE LIFE THROUGH IMPROVED MAINTENANCE"

PERSONAL HISTORY

WILLIAM A. BROWN

Born in St. Paul, Minnesota, October 12, 1937. He attended public schools in the St. Paul area, graduating from high school in 1955.

Mr. Brown served in the U.S. Navy as a Radioman and in the Seabee Reserve. He attended various trade schools, De Vry Institute, and Northern Montana College.

He entered service on the former Great Northern Railway as an Electrician Apprentice in August, 1957. Assigned various positions, including Assistant Roundhouse Foreman, Roundhouse Foreman, Diesel Supervisor, Power Maintenance Controller, Assistant Manager Motive Power, Manager Engines, and presently position of Superintendent Motive Power.

Mr. Brown has been a member of LMOA since 1976.

He is married to the former Patricia Crooks and they have five children. His hobbies are hunting and woodworking.

INTRODUCTION

As the cost of maintenance and materials rise, it is becoming increasingly important that improved preventative maintenance be provided to extend locomotive service life.

Preventative maintenance must include a compulsory routine check for leaks that effect locomotive life, efficiency and performance. Leaks from the locomotive are not only costly from a maintenance standpoint, they also contribute to cleaning of enginehouses, rights of way, and pollution control and disposal expenses.

Locomotive managers must continue asking for assistance from locomotive builders to improve the design and offer locomotives that remain free of leaks over extended periods of time.

1. COOLING SYSTEM LEAKS

Cooling system leaks will decrease the life of engine components, create road failures, increase out-of-service time and waste both material and manpower.

a. Live Engines —
External Inspection

Make an external inspection of radiators, pipe flanges and vent lines in the radiator compartment. Inspect all drain valves, cooling system piping, discharge flanges in the engine vee, water pump flanges and seals, lube oil cooler connections, sub-floor cab heater piping, water-cooled air compressor lines and appurtances, protective devices and radiator caps for leaks.

b. Dead Engine —
Internal Inspection

Shut down the engine, open cylinder test valves, remove all air box and crankcase covers, and drain oil from the strainer housing. Make a general inspection of the air box for liner and water jumper leaks and inspect the aftercooler cores of turbocharged units. If no leaks are visible, bar the engine over while thoroughly checking each assembly. When the strainer housing oil level has dropped, check

for signs of water leaking into the strainer from the lube oil cooler.

If additional inspection is necessary, hydro-test the engine using pressures outlined in mechanical instructions issued by your railroad. If no reason can be found for the water leaks, hydro-test the engine block, rechecking for leaks at the exhaust ports due to possible cracks in the exhaust scroll weld.

Member railroads have experienced failures in this area on 645 engines due to weld processing problems. A failure on a 645E3B engine at the No. 14 exhaust outlet elbow was investigated. The results would indicate a welding quality problem during manufacturing. These cracks can be repaired by carbon-arc air gouging and rewelding. Additional cracks have been found in the same area on other 645 series engines.

2. LUBE OIL LEAKS

Due to the large quantity of oil needed for the proper lubrication of the locomotive. it is economically important for the consumption of oil to be controlled.

In addition to the expense of adding oil, leaks effect overall engine performance, resulting in delays or road failures. Maintenance deficiencies, such as improper pipe clamping, covers and gaskets improperly applied, cross-threaded or loose connections, and overtorquing resulting in broken securements are the primary causes for oil leaks.

a. External Leaks—Gear Cases

The use of plastic gear case seals has greatly reduced the migration of gear lubricant from the gear cases. Instructions governing the application of the new plastic seals on EMD locomotives is covered in EMD maintenance instruction No. 9565.

General Electric has completed field tests for the AF motor style gear case gutters and seals and a new nonrubbing commutator and support bearing flange dust seal for an E8 motor. These materials are available from GE in kit form.

3. FUEL OIL LEAKS

The high cost of fuel dictates that we must conserve fuel in every manner. Fuel leaks, if not corrected, increase operating expenses, decrease engine efficiency and performance, create potential fire hazards and fuel contamination of the lube oil. An inspection of the entire fuel system must be made as required.

4. ELIMINATION OF LEAKS

Some problem areas highlighted in this portion of the paper have been corrected, now are being tested, or have been changed as follows:

GENERAL ELECTRIC LOCOMOTIVES

Cylinder to main frame leaks — a change to Viton gaskets.

Main frame core leaks — the use of Locktite, and now being tested, a new plug to accept Viton O rings.

Cylinder water elbows — changed to Viton gaskets.

Banjo tee — applied Locktite to all threads and change the one-piece construction.

Fuel pump O ring — change to Viton.

Cylinder jacket — added drainage grooves to reduce oil spills and changed cylinder head cover gasket to a higher temperature material.

Crankcase door gaskets — change both gasket and door shaft O ring to higher temperature material.

Governor gear box — eliminate external oil supply.

EMD LOCOMOTIVES

Gear case conversion to plastic gear seals.

Water piping conversion on WBO air compressors.

Modernization recommendations for differential pressure engine protectors.

Modification to the winterization system.

Update on engine coolant and the elastomer test for seals and gaskets.

In conclusion, good maintenance practices are essential to the elimination of leaks and the improved efficiency of the locomotive, thus reducing costs and extending locomotive service life.

TORQUING RECOMMENDATIONS

INTRODUCTION

This report deals with the basic functions of fasteners (bolts) and the proper way to install them.

The function of any fastener is to join two or more parts together with greater clamping force than the separation forces imparted by service loads. The torque values vary with the size, design and hardness of the bolts used.

Accurately measuring torque requires three things:

1. It is necessary to exceed the separation forces.
2. It is important to use enough clamping force to avoid minor separation of the joint.
3. Too much installation load may cause permanent structural damage to the bolt or nut.

The torque for specific bolts tightened to specified values is based on dry, solvent-cleaned threads unless otherwise recommended by the manufacturer. Application of any type of lubricant on the threads introduces an error into the torque measurement. If the recommended torque specification is achieved with a bolt that has been lubricated, the bolt may experience drastic and disastrous overloading, depending on type of lubricant used.

It is essential to determine whether the manufacturer's recommended torque specification is for a clean dry bolt or whether it is for a specifically lubricated one prior to installation and tightening.

A bolt should be tightened with smooth even pressure to avoid shocking the bolt to greater loadings than intended. (Impact wrenches cause vibration to shock a bolt to torque values above spe-

cified setting.) Most bolts will tend to relax lightly after a short period of usage. Once this relaxation has taken place (usually within the first few hours of operation) it should be retorqued.

A bolt is chemically and mechanically designed to do a given job. Nearly all bolts are made of alloy material and are heat treated or hardened to obtain desired tensile strength.

TORQUE WRENCHES

There are two basic types of torque wrenches that have been successfully manufactured. These are classified as the rigid frame torque wrench and the flexible beam type. A third type might be referred to as the clutch type.

Set or Seizure

In reaching a final correct torque reading, during last stages of rotation a set or seizing of the fastener is experienced. This is noticeable because during the final stages of the tightening operation there occurs a popping effect.

Should this set or seizing take place, it is necessary to break the set by rotating the nut or bolt in a back-off direction, and again apply tightening movement with the torque wrench by a steady sweep of the wrench, during which time the torque reading should be taken. This procedure is necessary since it has been found that a torque reading taken from a seized or starting position of the fastener is usually greater than the torque to which the fastener was originally tightened.

Breakaway Torque

The torque required to loosen a fastener (breakaway torque) will be in some direct relationship to the applied torque. Loosening a fastener by means of this breakaway torque test can determine the actual application torque.

A fastener can be tightened further to determine applied torque. Generally, this torque will be greater than the actual applied torque. It is desirable to make this test using a torque wrench having a memory recording feature. The operator then can concentrate on watching the socket to detect the precise moment that this moves. After movement has been detected, the memory style torque wrench can be checked to determine the precise torque value. This procedure has become the most widely used due to the narrow margin of difference between the applied torque and the torque required to set the fastener in motion in the tightening direction.

Proper Size and Range Of Torque Wrenches

Selecting the proper size and range of a torque wrench is important in obtaining accurate results. There are several considerations in selecting a torque wrench for a particular application. A good rule is to select a torque wrench having adequate capacity so that your working range is within the mid two-quarters of the scale.

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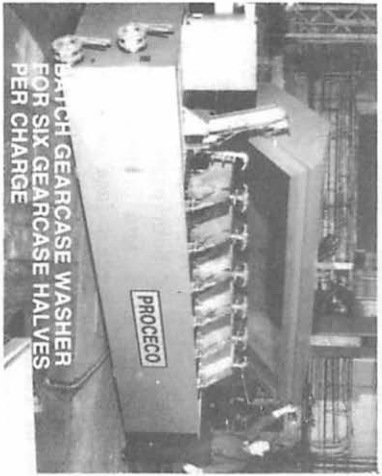

TORQUE WRENCH APPLICATIONS

To insure satisfactory performance of mechanical equipment and to avoid costly failures, it is important to tighten all nuts on vital bolts and studs according to values given in the appropriate instructions.

Use of Adapters

It is often necessary to use adapters with a torque wrench to reach inaccessible bolts or nuts. When adapters are used, the reading of the torque wrench dial is not the actual torque exerted. Additional torque exerted on the nut or bolt (over that shown on dial) depends on:

1. Length of the adapter.
2. Angle at which adapter is positioned on wrench.

NOTE: It is also very important that the threads of both parts be clean, free of burrs, and properly lubricated. The contact face of a nut or bolt must also be lubricated.

Use of Torque Multipliers

1. Determine amount of torque to be applied.
2. Select a multiplier with sufficient capacity for the job.
3. Select a torque wrench with proper drive square size and capacity to feed the multiplier. Another multiplier is frequently used as a "Go-Between" when requirements exceed 2000 foot-pounds.

The most popular torque multipliers use a gear ratio of 4 to 1. This device then either multiplies the torque for a given leverage length and force by 4, or it will allow one fourth the length of lever to be used. The formula for determining minimum leverage length when using a 4 to 1 multiplier is as follows:

Example: Torque Required 2,000 Ft. Lbs.

$2000 \div 100 \div 4 = 5$ ft.

$TW \div F \div M = L$

TW = Torque (Ft. Lbs.)

F = Force (Operator) (100 Lbs.)

M = Multiplier ratio (usually 4)

L = Lever Distance (Minimum)

The 4 to 1 advantage of the torque multiplier may be multiplied times 4 again, allowing a total mechanical advantage of 16 to 1. Another factor of 4 is used when two multipliers are used together:

$TW \div F \div M \div M = L$

A reaction bar is attached to the gear housing of the multiplier. This keeps the unit from turning as torque is applied. As the torque increases at the input, this torque at the output drive also increases, as does the force generated by the reaction bar. Since the forces at the reaction bar can be considerable, the device against which the reaction bar rests on the job must be determined as being strong enough to sustain the load. The amount of torque at the reaction bar is the difference between the input and output torque.

CARING FOR THE TORQUE WRENCH

Zero setting the indicating pointer or pointer tip is a minor repair that can be performed in the shop

by anyone. Minor adjustments can be made by using a pair of pliers and bending the soft metal pointer tip. To place the tool in accurate working condition, properly align the pointer so that it inersects the zero increment marking as the tool lies in a rest position.

If the head end of a torque wrench is loose from the measuring element, or if the yoke of the torque wrench is loose from the measuring element, it should be returned to the factory for repair. Continuing to use a tool in this state will increase looseness and reduce the chances to repair the tool and place it in first class working condition again.

The measuring element of all popular torque wrenches today will eventually fatigue. Flexible beam torque wrenches remain permanently accurate up to the very moment of fatique when the measuring element fractures and separates. At this point the tool is no longer usable, and there is no chance of using the tool in an inaccurate state.

Torque wrench accuracy should be checked daily with an analyzer at the beginning of each work shift. Check accuracy before each use on maintenance work.

Dry assemblies of bolts and nuts require higher torque than lubricated bolts and nuts. If threads are not clean, the values may be higher yet.

Cadmium plating or well-rolled and lubricated bolts mating with smooth threads in a tapped hole may require as much as 20 percent less torque.

General Electric Torque Check For Bolted-On Crankshaft Counterweights

If an engine has one or more bolted-on counterweights on its crankshaft, it is suggested that bolt torque should be checked at the same time connecting rod or main bearings are replaced. Use special ratcheting torque wrench with 1⅛ inch socket. To make the torque check (400-425 ft. lb. value) on a crankshaft inside the engine, an extension between handle and socket is required.

General Electric Cylinder Hold-Down Bolts

It is important that cylinder hold-down bolts be tightened to proper torque values — no less, but no more than 1300 to 1400 ft-lb. Be sure no oil, water, or foreign material is in cylinder hold-down bolt threaded hole. Under-torquing of a hold-down bolt may result in eventual failure. The cylinder is permitted to move in operation, resulting in work hardening of the bolt, and eventual separation of the bolt head from the shank. If one hold-down bolt fails in this manner, it is very likely that same failure will be repeated on the remaining bolts.

If hold-down bolts are overtorqued, there is danger of the bolt breaking while being torqued. An excess amount of torque will be required to break loose an overtorqued bolt. About 20 percent more torque is required to loosen a


3510
3510
WP
5457
5457
CONRAIL
6311
6311
SP

bolt that has been tightened to specified torque. In cases where it is necessary to apply heat to remove the hold-down bolt, the bolt must be scrapped because the heat affects the heat treatment of alloy material.

The hold-down bolts can be properly torqued by using the Pneutorque Cylinder Hold-down Kit with a half inch diameter hose and air pressure regulator set at 43 psi unloaded, or the old-type hand operated Cylinder Hold-down Bolt Wrench which is a 12 to 1 multiplier wrench, setting of 110 to 115 ft.-lb. input by a torque wrench.

EMD Oil Out The Stack And Broken Crab Bolts

One of the reasons for oil out the stack of EMD 645 engines is excessive wear in the head seat ring contact area. The oil that accumulates at base of head at head seat ring is pumped out the exhaust by venturi effect of worn head seat and head seat ring. Water leak is an indication of worn head seats. This wear can be kept to a minimum by in-service tightness checks on new and rebuilt equipment, retorquing the crab nuts annually, and by applying the correct torque when a power assembly is installed.

Head retainer wear should be measured whenever the power assemblies are removed from an engine. Engines with head retainer wear steps greater than 0.010 inch maximum should be machined to resurface the head retainer. The wear step can be measured using the gauge shown in EMD Maintenance Instruction MI-316A. This MI also provides the information necessary to measure the head retainer wear step and to perform the resurfacing operation using tools available from Electro-Motive.

If engine crankcase is scheduled to be line bored, it is recommended the line bore operation be performed before the head retainer resurfacing operations. A change in dimensions between the head retainer surface and the crankshaft centerline may result due to line boring. This dimension is critical for the selection of proper thickness head seat ring.

After machining, the head retainer surface to crankshaft centerline distance is restored to approximately original dimensions by using oversize head seat rings, which are available either .018" or .038" over the standard .192" thickness. To standardize the engine, oversize head seat rings should be installed only in full engine sets. It is important to determine the piston to head clearance after machining the head liner surface. This will provide the final criteria for selection of the proper thickness head seat ring. When engine is assembled, stencil oversize head seat ring information on each side of engine crankcase. Clearance should be .020" min. to .068" max.

Although the above procedure is available, the committee recommends staying with standard head seat rings by welding head seats and machining to standard dimensions.

Another item that affects the wear in the head seat ring contact area is the wear on the inside diameter of the lower liner insert. Whenever the power assemblies are removed from an engine and the inside diameter of the insert reaches the maximum limit of 10.386 inches, the insert should be removed and a new one installed. EMD has available a lower liner insert and removal tool specifically designed to do this work. Inspect crankcase lower insert bore dimension. Build-up and remachine if dimension exceeds 11.068" maximum. Whenever cylinder liners are removed and reconditioned the outside diameter at bottom of liner should be 10.371 inches to 10.3755 inches.

One of the reasons for broken crab bolts is under-torque. This breakage can be kept to a minimum by in-service tightness checks and retorquing crab nuts annually. Crab bolt threads can be cleaned using 1¾ inch-12 UNR thread die; crab nut threads may be cleaned using 1¾ inch-12 UNR tap. Only the UNR type thread die should be used to prevent damage to rolled threads.

If one of the two crab bolts located at either end of either bank, or one of the center crab bolts on 16 or 20 cylinder engine has broken, the other three bolts holding the cylinder head should be changed. If a broken crab bolt was in any other location, the remaining five crab bolts holding the heads held by the broken crab bolt should be changed.

EMD has recently introduced new design plate crabs in 50 series engines. Plate crabs are now available for retrofit on existing engines. Plate crabs are torqued to 2400 ft-lb. and do not require annual retorquing. Old style crabs must not be machined to new style because of the difference in manufacturing processes.

Improved Rocking Piston Pin Insert Bearing Retainer System On EMD Model E3B Engine

Railroads report problems with the piston pin insert bearing retention system on EMD Model E3B engines. This problem can be suspected when following symptoms are experienced:

Excessive thrust washer wear;
High lead content in lube oil;
Foreign material in oil sump or strainer housing;
Oil on hood;
Heavy exhaust.

This system consists of retainers fastened to the carrier with a bolt and locking clip arrangement at either end of the insert bearing as shown in Figure 7. A number of development steps have occurred since original design retention system. The following are the latest design components.

Retainer bolt 9547667 is a 1/4"-20-SP bolt with a pre-applied dry thread lock compound. The bolt incorporates an interference-type thread form.

Locking clip 9536664, which incorporates many changes — most notably the addition of a locking tab to prevent rotation.

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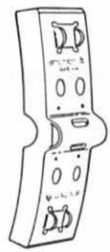

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Retainer 9548905 with more than double the strength of the original design. Can be identified by rounded corners.

The improved design bolt and locking clip are for one time use only. They should be discarded and replaced with new parts whenever carrier is disassembled.

Inspection and assembly instructions in EMD Pointers 8L-82 must be followed whenever carrier is disassembled.

Check Engine Torque

It is recommended that each railroad establish a procedure to check torque per builder's recommended practice on new or rebuilt engine and complete cylinder assembly changes. Checklist can be used for this requirement.

Update On Fuel-Efficient Locomotives

In 1980 this committee covered fuel conservation and the latest fuel-efficient designed locomotives and various hardware available to retrofit and upgrade older locomotives.

We presented available options and the published percentage of fuel savings over the older locomotives. These improvements were identified by using 1971 as the base line and a medium duty cycle for calculations. Each railroad could then determine its own participation and costs and the ROI by the reduced fuel consumption for gross ton miles.

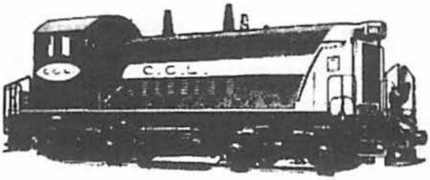
This committee felt it should update and review the changes that have occurred and will continue to occur. Railroads, locomotive builders and the supply industry will continue to develop and improve the latest innovations and equipment in order to maintain the desired fuel cost savings.

We did not intentionally delete or ignore Canadian efforts toward the same goal of producing a reliable fuel efficient locomotive. But we did not have the necessary input from Canada.

We feel very fortunate to have with us on this committee a representative from the Bombardier Company of Canada, a locomotive builder that is deeply involved and dedicated to producing fuel-efficient locomotives. Like the other locomotive builders, the Bombardier Company has attained improved efficiency over the older model locomotives. Several improvements made include: Reduced parasitic loads, restructuring of notch/power curve, improved exhaust manifolds, improved control systems reducing smoke (thus giving optimum control), and the ability to conduct testing for actual engine improved specific fuel consumption.

In our 1980 paper we covered the EMD locomotive equipped with the E3B diesel engine and the rated improvements over the E3 engine using the fuel economy turbocharger and the .500 inch injector. We also mentioned the two-speed dynamic braking.

New SD40-2 locomotives produce a fuel savings of 6.9 percent over locomotives built prior to 1980 with



the following changes that help achieve these savings:

The E3C diesel engine configuration;
F3A modified turbocharger;
Fire ring 16:1 compression ratio piston;
200 RPM low idle;
200 RPM to 4th notch two-speed braking;
Traction motor blower change;
Increased radiator size and three 4-bladed cooling fans;
Modified traction motor blower duct;
Straight through exhaust silencer;
Two-speed cooling fans.

The SD50 locomotives for this same period of time produce savings of 9.7 percent over the first SD50 model locomotive. Retrofit programs would include the following:

F3A modified turbocharger;
Fire ring 16:1 compression ratio piston;
200 RPM low idle.
200 RPM to 2nd notch 2-speed braking;
Traction motor blower change;
The 3½ core radiator bank which requires radiator hatch modification;
Three four-bladed cooling fans;
Straight through exhaust silencer
Two-speed cooling fans;
AR-11 alternator.

In any retrofit program it is important to point out some areas that must be considered, such as the necessity to apply the third generation 18 KW AC auxiliary generator, rework the traction motor blower duct, and rework the radiator hatch to accommodate the 3½ radiator banks. And again, each railroad must determine costs and develop its own ROI for these conversions.

We discussed the many changes that were made on the General Electric locomotive that produced estimated fuel savings of 7.5 percent over locomotives built prior to 1980 by reduced horsepower requirements on equipment blower, radiator cooling fan, the low idle feature, 1616B2 turbocharger and a modulated engine speed schedule for dynamic braking.

General Electric has developed for retrofit to older locomotives the Eddy current clutch for controlling the drive of the vertical fan, thus reducing this costly parasitic load, when engine cooling is not required. This is estimated at an additional 6.0 percent which includes the reduced horsepower fan and gear box. Also available to produce estimated saving when applied in full engine sets is the 18 MM double helix fuel injection. pump which is .5 percent to 1 percent.

General Electric has announced its new locomotive design. It reduces the mechanical parasitic load of the vertical cooling fan by replacing with electrically driven cooling fans. Also, the dynamic brake grids were relocated and the heat dissipated by an electrically driven blower.

While each locomotive builder spends millions of dollars in research and development to achieve the ultimate in fuel saving and reliability, unless users dedicate their efforts to implementing and control of the various key elements of proper application, inspection and maintenance, they will not obtain these cost saving benefits over the life of the locomotive.

Inattention to some of these factors could conceivably negate these benefits and even cost far more than the fuel cost savings. Such factors include:

1) Dirty aftercoolers result in high temperatures in the air intake system, seriously impacting fuel consumption and increasing exhaust temperatures. This can also lead to premature exhaust valve failure, as well as turbocharger failure.
2) Improper maintenance of air filtration system.
3) Poorly maintained fuel injection equipment.
4) Dirty radiators.
5) Delayed intake port cleaning.
6) Not repairing all air, lube oil, fuel oil and water leaks.

Just consider the negative effect of about a 6 percent loss in fuel savings if these important areas are ignored. Only through good maintenance practices can we realize fuel savings and over the long range reduce our mechanical repair expenses.

Radiator Screens

This portion of the committee presentation discusses development and recommendations relative to use of radiator screens.

Until recent years radiators were more or less neglected in terms of replacement or repair charges, failures, locomotive down time, handling expense, and so on.

Many of us accepted failures as something to be eventually expected. When they did occur, very little was accomplished other than replacement of the defective radiator with a new or reconditioned core.

Little if any investigative effort was applied to determine causes of failure. Few analyses were made of the defective cores to assure that reconditioning would be economical by comparing replacement versus repair costs. Repairs were repeated time and time again, many times perpetuating a defective core to the extent repair and handling charges far exceeded cost of purchasing a new replacement radiator.

About five years ago a major railroad began a cost and reliability study on a group of locomotives equipped with large solder-type radiators.

At that time, a policy was in effect to repair a maximum number of defective cores and return them to service. No consideration was given to number of previous repairs, age of cores, etc.

It was found that a 100 percent turnover of total population of ra-

diators within the study group would occur approximately every five years. Repair charges alone would exceed the cost of total replacement in a similar period of time.

The total cost was incalculable due to records of out-of-service time, and labor charges were not recorded.

Based on the preceding, replacement with new improved design radiators was the only economical path to follow.

Wasteful practices were discontinued, older failed cores were designated nonrepairable and scrapped, restrictions were placed on repair procedures, and handling guidelines established.

These policies or specifications were published in a recent Diesel Mechanical Committee report, and have since been adopted by several railroads, many of whom report significant improvement in reliability, increased longevity, as well as substantial total maintenance cost reductions.

At this point, all of us would have felt confident in saying we've established control or learned to manage a maintenance component on the locomotive that involves a tremendous amount of money.

There is, however, an additional step to take or goal to achieve, that is, to extend service life beyond what we are experiencing today.

This committtee strongly advocates installation of radiator screens as a means to achieve that goal.

Over the years there has been considerable discussion and opinions concerning the use of radiator screens. There was justifiable concern over down time, labor expense and possible handling damage that could occur removing radiator banks periodically to change or clean screens. Deferred radiator screen maintenance evenually would lead to overheated engines and possible expensive unscheduled overhauls. Also, it was noted only a small percentage of radiator cores exhibited tube plugging that required extensive cleaning and rodding to rehabilitate.

Radiators in service with a high percentage of debris or scaled plugged tubes will experience increased water flow velocity and pressure within the remaining open tubes. If this condition is allowed to continue uncorrected over a long period of time, tube erosion will occur.

A radiator in this condition requires extensive cleaning and rodding of plugged tubes to rehabilitate to serviceable status. Erosion weakened tubes combined with excessive cleaning measures will effectively reduce the total service life of a radiator.

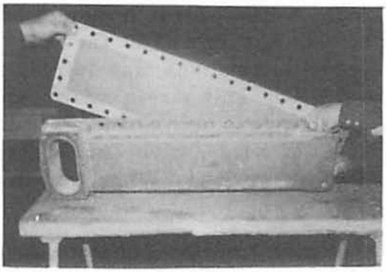
As indicated, many railroads see only a small percentage of radiators with severe scale buildup or plugged tubes. EMD locomotive cooling systems are constructed with banks of up to six radiator cores in series. These banks, if not protected by a screen, effectively act as a filter within the cooling system. Usually the core positioned next to the inlet header accumulates a majority of debris or scale present and will eventually exhibit plugged tubes. The remaining cores downstream remain relatively clean. This, therefore would account for the small percentage of cores observed with plugged tubes.

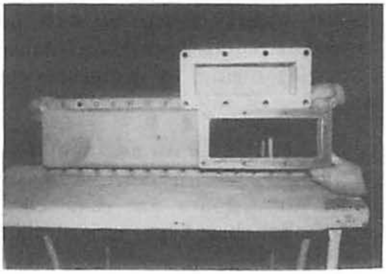
If, for example, during scheduled overhaul you found one out of twelve SD40-2 double length 6-row cores with plugged tubes, then 25 percent of that group of locomotives has severe cooling system problems, and the potential exists for a severe overheat-type engine failure.

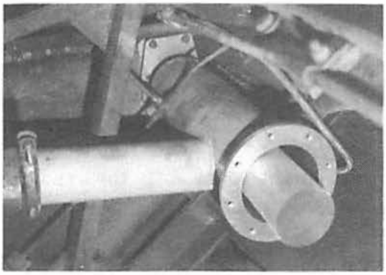
There currently are three types of screens available for installation in EMD locomotives. EMD originally provided and promoted use of a header screen that fit or was sandwiched between the radiator core and inlet header.

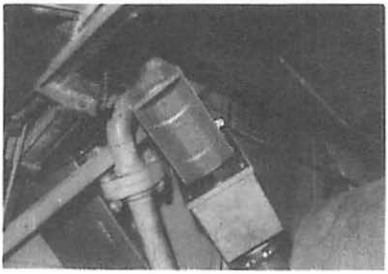
This type of screen adequately provided desired protection of the radiator cores; however, screen maintenance required removal of the entire radiator bank from the locomotive and disassembly of the inlet header. Depending on operation and water treatment conditions, maintenance intervals were required as frequently as once a year.

It was estimated an average of nineteen manhours and eight locomotive down time hours were required to accomplish screen maintenance. This figure would fluctuate depending upon shop space, cranes, labor forces, etc.









In recent years, a new model screen applicable to the Dash-2 series locomotives was introduced by EMD. This screen known as a "box" type is designed to fit in the radiator header piping as opposed to the previous design that was part of the radiator bank.

Removal of the radiator header piping is required to accomplish box screen inspection or maintenance. Maintenance of the box screen is required at more frequent intervals owing to decreased surface area of this screen.

It is estimated an average of six manhours and three locomotive down time hours are required to accomplish box type screen maintenance

The third model screen available was developed by Diesel Radiator Company and is applicable to 38-40 and 45 and Dash-2 series locomotives. These screens are known as Y or T type strainers and are designed to fit, and function as a permanent part of, the radiator header piping.

The "T" strainer is applicable to 45 series locomotives. One end of the strainer housing has a mating flange that bolts to the radiator header; the opposite end is sealed and clamped in place by the engine wye pipe marmon coupling.

Maintenance interval can be extended further than the original header type due to increased surface area of the cylindrical screen.

Maintenance or inspection of the "T" type screen involves removal of a bolted cover and changing or cleaning the screen unit.

It is estimated that an average of one-half man hour and one-half locomotive down time hour is required to accomplish maintenance.

The "Y" strainer is applicable to 38-40 and Dash-2 series locomotives. Due to close clearances within the engine room compartment, this screen assembly is smaller than the "T" type and is designed to replace the engine wye pipe marmon couplings. Installation requires removal of existing marmon couplings and replacing them with the "Y" strainer assembly.

Maintenance interval is somewhat less than the "T" type strainer owing to decreased screen surface area.

Maintenance procedures, labor and down time are similar to that of the "T" type screen.

Following is recap of available screen data:

EMD 6-ROW RADIATORS 38-40/-DASH-2 LOCOMOTIVES

Model	Surface Area	Mtce. Interval	Maint. Man Hours
EMD Header Screens	180 sq. in.	12-24 months	19
EMD Box Screens	130 sq. in.	6-12 months	6
Diesel Rad. "Y" Strainer	157 sq. in.	12-24 months	½

EMD 8-ROW RADIATORS—45 SERIES LOCOMOTIVES

Model	Surface Area	Mtce. Interval	Maint. Man Hours
EMD Header Screens	238 sq. in.	12-24 months	19
Diesel Rad. Strainer	260 sq. in.	12-24 months	½

With the advent of these newly designed screen assemblies, prohibitive maintenance and down time costs have been reduced to a relatively insignificant amount and, therefore, as previously indicated, this committee is of the opinion that installation of new type radiator screens will increase total service life and improve reliability of EMD locomotive radiators.

The General Electric Company and Bombardier Corporation never provided a radiator screen in their cooling systems. GE provides a screen to filter debris from the oil cooler assembly; however, it is down stream from and does not provide protection for the radiators.

The railroad members of this committee are also of the opinion that screens are needed to improve service life of GE and Bombardier radiators and respectfully suggest both manufacturers consider development of a low-maintenance radiator screen.

ALTERNATIVE STARTING SYSTEMS

INTRODUCTION

The problem of starting diesel engines has existed from the day Dr. Rudolph Diesel started his first one-cylinder, coal-fired diesel engine with an explosive charge placed in the combustion chamber.

In February 1924, the first commercially successful diesel-electric locomotive was unveiled by the General Electric/ALCO/Ingersoll-Rand consortium. This locomotive was powered by a four-stroke cycle 10"x12" Ingersoll-Rand diesel engine matched with G. E. electrical equipment, inside a carbody built by ALCO. The unit was rated at 300 horsepower for traction, and weighed 60 tons. All early GE/ALCO/I-R and Westinghouse/Beardmore locomotives were started by air, but not by the air-starting method we know today. A gasoline-driven Mianus air compressor fed a pneumatic distributor, which was designed to inject compressed air (at 200 psi) into each cylinder at top dead center position. This air injection starting system was plagued with maintenance and cold weather starting problems, despite a coal stove that provided standby heating of the engine room.

Electric starting was introduced on a GE/ALCO/I-R 300 horsepower diesel-electric switching locomotive in December 1926. Hermann Lemp's research team at General Electric added a starting winding to the main generator, enabling the main generator to act as a starting motor with energy provided by storage batteries.

Main generator electric starting worked well for forty years until the advent of the first AC/DC driven locomotive, an ALCO model C-630 delivered to Atlantic Coast Line in July 1965. Since a traction alternator cannot be utilized as a starting motor, the three builders had to develop alternative means for starting the diesel engine. The alternatives explored were:

1) **Air Motor Starting** — This system utilized a starting air receiver that was charged by the locomotive's air compressor. Compressed-air energy was applied to the flywheel during cranking by two vane-type air motors. EMD experimented with air motor starting during 1964-65, but eventually settled on dual electric starting motors.

ALCO and Montreal Locomotive Works (now Bombardier) chose to offer an Ingersoll-Rand air motor starting system as basic on all locomotives with AC/DC transmission. This air starting system was very successful, exhibiting high reliability and low maintenance characteristics. ALCO used air starting from 1965 to the end of production in 1969, and MLW (Bombardier) used air starting until General Electric applied starting windings to auxiliary generators and exciters.

2) **Electric Starter Motors** — Dual electric starter motors applied

INSTALL ONE OF THE VERSATILE

KIM HOTSTART PALLETIZED COMBINATION HEATING SYSTEMS AND ELIMINATE EXPENSIVE LOCOMOTIVE IDLING

COOLANT ONLY—COOLANT & LUBE OIL—COOLANT & DIESEL FUEL—OR A TRI-COMBINATION TO HEAT ALL THREE—BATTERY CHARGER OPTION AVAILABLE ON ALL SYSTEMS

SYSTEM OPERATION

Engine coolant is circulated through an inner heat exchanger tank containing the heating element by means of a centrifugal pump. Engine lube oil is circulated through an outer tank (surrounding the inner tank) by means of an internal gear driven pump. If the diesel fuel is also to be heated, then an additional heat exchanger tank and fuel circulating pump is required.

SYSTEM FEATURES

- 100% return on investment in one year.
- Annual fuel savings of 12,000 gallons per locomotive.
- Maintains desired engine block temperature while locomotive is shut down.
- Self contained components are palletized and pre-wired and made into a compact industrial package.
- Solid state remote alarm system plus additional safety control features.
- Electrical-mechanical flow type heating system and controls assures absolute minimum maintenance.

SYSTEMS ARE AVAILABLE IN 18,000, 24,000 & 48,000 WATTS AT 240, 480 & 575 VOLT, THREE PHASE

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P.O. BOX 42 SPOKANE, WA 99210
TELEPHONE — 509/534-6171

energy from storage batteries to the diesel engine flywheel.

General Electric utilized this starting method until it modified auxiliary generators and exciters for starting duty.

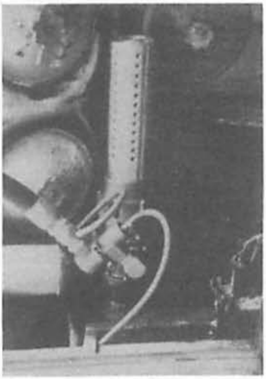
EMD adopted this method as basic on all locomotives with AC/DC transmissions, and still offers the system at present.

3) **Auxiliary Generator / Exciter Cranking** — General Electric added starting windings to the auxiliary generator and exciter, which were DC machines. This allowed the alternator/exciter to apply storage battery energy to the diesel engine crankshaft through a geartrain. General Electric and Bombardier currently offer this system as basic on locomotives with AC / DC drives.

Alternatives to electric motor starting are being explored today due mainly to fuel conservation efforts in the railroad industry. Many railroads are shutting down locomotives that will not be utilized within an hour, at ambient temperatures as low as 33°F. Electric motor starting suffers two disadvantages under these conditions. First, the higher duty cycle involved in starting and shutting units down more often is claiming an unacceptable mortality rate on electric starting motors. Second, electric starting systems suffer impaired effectiveness in cold weather. Alternative starting systems currently being marketed are as follows:

Tech Development, Incorporated Series 52A — Turbine Type Air Starter

The Series 52A is a heavy duty turbine-type starter motor, which can be used to start carburated engines in the 25,000 C. I. D. range or diesel engines up to 15,000 C. I. D. It can be used over a wide range of drive pressures (40 psig to 150 psig). The motor will deliver up to 155 horsepower at the highest pressure input and pinion speed of 2550 rpm at turbine speed of 30,000 rpm.



The makeup of the starter consists of an impulse turbine driven through integral planetary gears to an inertial starter mechanism.

The turbine wheel of the Series 52A is aluminum and relatively lightweight, which facilitates smooth pinion engagement and reduced forces of the pinion ring gear mesh at the instant of engagement.

The bearing and gears of the series 52A motor are grease lubricated for their entire life. The drive housing is cast iron and has an outboard roller bearing capable of

withstanding the heavy separating loads on the drive pinion to ring gear mesh.

No oil is required in the drive air of the Series 52A motor which results in no failures because of poor lubrication; reduced expense because no oiler or related connections are required; and exhausted air carries no oil.

Turbine-type motors are unaffected by temperature extremes, oil, and moisture freezing.

To date the committee is aware of one railroad application of the Tech Development Series 52A to a SD45 diesel electric locomotive. Because of certain technical problems, the locomotive is not presently equipped with the Tech Development system. Failures of the turbine shaft and turbine wheel, have been experienced to date.

The approximate cost of the kit for the Series 52A Air Starter System is $1,500.00, plus air reservoir and hardware.

Ingersoll-Rand SS 825 Series Heavy Duty Air Starting Systems —Vane Type Starter Motors

The SS 825 is IR's latest series of reliable starting motors for heavy duty diesel engines.

Dual starting motors are utilized on 16 and 20 cylinder EMD diesel engines. The motors are of the multivane type consisting of a rotor, which is supported at each end by ball bearings, offset reduction gear train, and a drive mechanism. First, pilot air is routed to the drive piston assembly, extending the pinion and engaging the

pinion with the ring gear. Once the pinion is fully engaged, the pre-engagement circuit is completed, actuating the main relay valves. Compressed air strikes the vanes, which slide in the rotor, causing the pinion of the rotor to rotate and turn the drive mechanism through a set of planetary gears.

The motors utilize standard main reservoir air pressure for starting. The system with a 140 psig charge on the locomotive air brake reservoirs are able to provide a minimum of one sixteen-second start.

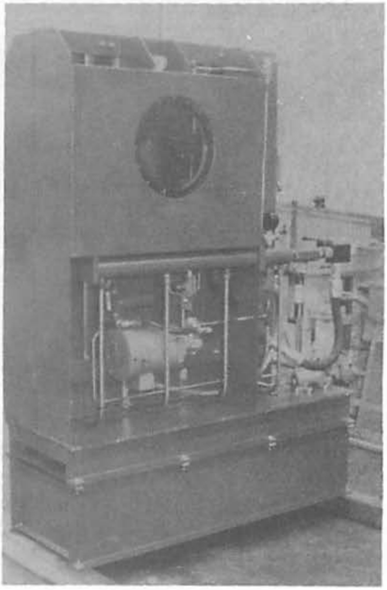
Ingersoll-Rand has developed an engine purge, or a slow accelerating starting system that will insure the engine will turn under 30

RPM for the first 1 to 1½ revolutions to prevent the possibility of hydraulic lock damage during engine starting. Thereafter full air pressure is supplied to the dual motors to rotate and start the engine.

As of this writing, there are two large U. S. railways testing EMD SD40-2 and SD45 locomotives equipped with the Ingersoll-Rand SS-825 dual starter motors. The tests have been in progress for more than nine months, with virtually trouble-free operation. Prospects for additional applications of air start systems look very favorable. The approximate cost for the IR System complete is $4,000. EMD and Bombardier utilize IR Systems on marine and industrial applications and certain export applications.

American Bosch Hydrotor Fluid Power Cranking System CMD-3A (Hydraulic Cranking System)
Distributed by
Illinois Auto Electric Company.

The hydrotor cranking system operates on the principal of hydraulic fluid under pressure turning a fluid power motor to produce mechanical energy. The hydraulic fluid in the system is stored under high pressure in high-presure hydropneumatic piston-type accumulators and released to the hydraulic cranking motors through a control valve, which can be either electrically or manually operated.



The high pressure hydraulic fluid enters the 8-hp to 60-hp output

cranking motor through the inlet port and is directed against a series of free pistons within the steel rotor assembly, which is splined to the drive shaft. When the pistons receive the pressurized hydraulic fluid they move forward against the inclined thrust bearing, causing a rotation of the rotors.

The drive shaft carries the Bendix drive, which is engaged with the engine ring gear. The hydraulic fluid is then returned to the outlet port of the hydraulic motor.

The 8 to 60-hp hydrotor motor has a cast aluminum housing with a drive shaft supported by two needle bearings and center ball bearing for low friction starting over a wide temperature range. All size models utilize a steel rotor assembly with seven free pistons.

The hydrotor system incorporates a cabinet containing the accumulators, hydraulic pump, reservoir, filters, and accessories. As an example, four accumulators are required for a twenty cylinder EMD engine application. A fully charged system will provide a single 20-second crank at 60 rpm. An electrically driven pump is basic to the system for the purpose of recharging the accumulators (time required is 25-30 minutes when system is fully discharged). An independent hand pump may also be utilized to recharge the accumulators.

The approximate cost of the hydrotor system is $8,500.

CONCLUSION

All of the alternative starting systems that were discussed in this paper show some measure of promise. Further field testing is required before a recommendation can be made on the preferred starting system or systems.

One possible benefit that could be realized from using a non-electric starting system is a reduction in storage battery capacity. Extra battery capacity now needed for cranking could be eliminated at a substantial cost savings. This committee is unaware at present of the exact minimum battery requirements should the need for starting power be eliminated. More investigation is needed in the area of storage battery requirements.

NOTES

1) Cold weather tests conducted in Alaska on non-locomotive engine.
2) Under development.
3) Slow accelerating system also available. Crankshaft rpm after one revolution is 25-30 rpm; EMD does not consider the slow accelerating system to be purge control.
4) Under development
5) Due to projected high failure rate.
6) System also available with no separate storage volume.
7) Alco and Bombardier offered 280 amp-hr battery sets standard with air-start locomotives.

L.M.O.A. COMMITTEE ON DIESEL MECHANICAL MAINTENANCE

ALTERNATIVE STARTING SYSTEMS - COMPARISON CHART

COMPARISON CRITERIA	Tech Development Series 52A Air Starter	Ingersoll-Rand SS-825 Air Starter	American Bosch Hydrotor Starting System	Electric Starting Motors (32 VDC)
Initial Cost	$2,000 (approx.)	$4,000 (approx.)	$8,500 (Approx.)	$2,966.65
Cold Weather Cranking Characteristic	GOOD	GOOD	GOOD [1]	POOR
Purge Control Available	NO [2]	YES [3]	NO [4]	YES
Reliability/Durability	POOR	GOOD	UNKNOWN	FAIR
Maintenance Cost	HIGH [5]	LOW-No Specified Mntnce. Interval	UNKNOWN	HIGH
Lubrication Requirements	NONE	ADD 6 OZ. Fuel Oil to Lubricators Every 90 Days	NONE	NONE
Starting Motor Weight	50 lbs. Each (1 Motor)	95 lbs. Each (2 Motors)	40 lbs. Each (2 Motors)	79 lbs. Each (2 Motors)
Starting Motor Length	21.0"	17.6"	18.2"	18.5"
Starting Motor Dia. (Nominal)	6.0"	10.0"	5.1"	6.0"
Mounts in S.A.E. Mounting Flange	YES	YES	YES	YES
Type of Starting Drive	Inertia Engagement Drive	Pre-engaged Drive	Inertia Engagement Drive	Inertia Engagement Drive
Drive Pressure	130 psig (air)	130 psig (air)	3,000 psig (hydraulic fluid)	-
Horsepower at Drive Pressure per Motor	118 HP	60 HP	60 HP	51 HP at 650 amps
Starting Motor RPM at Drive Pressure	30,000 RPM	2,500 RPM	3,000 RPM	1,100 RPM
Cranking Capacity at Drive Pressure	One 8-Second Crank at 55 RPM	One 16-Second Crank at 60 RPM	One 20-second crank at 60 RPM	-
Sound Pressure Levels (at 1 Meter)	125 dBa	110 dBa	Unknown	-
Storage Tank Volume	20 cu. ft.	20 cu. ft. [6]	15 gal. (hydraulic fluid)	-
Cost of Battery Set [7]	$2,000.00 280 amp-hr	$2,000 280 amp-hr	$2,000 280 amp-hr	$2,418.00 420 amp-hr

DIESEL MECHANICAL MAINTENANCE

Six-Year Index

1982

Quality Maintenance — The Key To Fuel Conservation

1. Fuel Conservation — Effects on Maintenance
2. Fuel Conservation — What It Costs
3. Diesel Fuel Receipt and Disbursement
4. Turbochargers

1981

Increased Service Life Through Improved Technology

1. Running Gear
2. Filtration
3. FRA Rules
4. Follow-up on Previous Topics

1980

Fuel Economy through Improved Maintenance in the Coming Decade

1. Fuel conservation
2. Winterization
3. Utilization of on-board load test
4. New FRA Rules
5. Welded crankshafts

1979

Maintenance for High Reliability

1. Welded crankshafts
2. G. E. power assemblies
3. Assigned maintenance terminals
4. Radiators
5. Dye and cooling system
6. Air compressors
7. Viscous and gear dampers
8. Hard bore liners
9. Progress toward elimination of oil leaks.

1978

Problems, Causes, Prevention and Repairs

1. Power assembly water leaks —E. M. D.
2. Turbos—Diagnosis of failures to replacement
3. Winterization
4. Update
   a. Viscous dampers
   b. Grooveless connecting rod and main bearings — G. E.
   c. Solid low pressure fuel lines — G. E.
   d. Air compressor

1977

Better Management of Mechanical Maintenance

1. Air compressor
2. Crankshaft failures
3. Vibration dampers
4. Fires — mechanical
5. Road failures

Southwestern Railway Club

Started in 1946, the Southwestern Railway Club this year is celebrating its 37th anniversary.

The organization consists of 246 Railroads and 394 Railroad Supply members who co-operate to discuss locomotive and freight car maintenance and other aspects of the Railroad Industry.

Railroad personnel and Railroad suppliers and builders are welcome members in the Southwestern Railway Club. Meetings are held three times a year at which various presentations are given — 4th Thursday of October in Ft. Worth, TX; 4th Thursday of January at Houston, TX; 4th Thursday of April at Little Rock, AR.

Application for membership should be directed to the Secretary-Treasurer, Southwestern Railway Club, P. O. Box 716, St. Louis, MO 63188.

J. R. WILSON
PRESIDENT
Superintendent Freight Car Shops
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Springfield, MO 65802

G. W. LINKER
SECRETARY-TREASURER
Supervisor of Mech. Equip. D/S
Missouri Pacific Railroad Company
St. Louis, MO 63103

Tuesday, September 20, 1983

9:00 A.M.

REPORT OF THE COMMITTEE ON DIESEL MATERIAL CONTROL

Pre-Convention Presentation: Southwestern Railway Club

April 21, 1983 Camelot Inn Little Rock, AR

M. L. WALL, Chairman
Superintendent Motive Power
Missouri Pacific Railroad
St. Louis, MO 63103

VICE CHAIRMAN

L. C. Showers, Manager Cost Control, Union Pacific Railroad Co., Omaha, NE

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1983 TOPIC:

"MATERIAL SYSTEMS - ACTION THROUGH NEW IDEAS"

PERSONAL HISTORY

MICHAEL L. WALL

Michael L. Wall was born in East St. Louis, Illinois, on August 31, 1945. He graduated from the University of Missouri — Rolla in August, 1967, with a BS degree in Mechanical Engineering.

He was employed by Missouri Pacific Railroad in St. Louis on August 7, 1967, and has held mechanical officer positions at various locations on the MoPac system. He returned to St. Louis as Superintendent Motive Power in May, 1979.

He is Chairman — LMOA Diesel Material Control Committee, Director—TTD Implementation Officers Mechanical Equipment Group, Chairman—AAR Alternative Fuels Steering Committee, Member—AAR Locomotive and Electrical Equipment Committee, Vice-President—Southwestern Railway Club, and Member — American Society of Mechanical Engineers.

Mr. Wall is married to the former Judy Wright and they have one daughter named Rebecca.

INTRODUCTION

The theme of the 1983 Diesel Material Control Committee paper is entitled "Material Systems - Action Through New Ideas". There has been considerable activity in material management systems and in methods to ensure that material is available when needed. As locomotive maintenance officers, we may have a tendency to relegate material acquisition to a lower priority since we are not directly responsible. However, as end users, we must become intimately involved and interested in how material is obtained, the quality of material, inventory levels, and many other areas not directly related to locomotive maintenance. Our ability to manage material affects not only our budget but also the corporate bottom line.

The subjects presented by this committee are intended to acquaint mechanical officers with material systems and also provide practical ideas on how to reduce maintenance costs and improve productivity. The subjects to be presented are:

A. Improved Locomotive Productivity Through Computerized Data Transfer

B. Inbound Material Inspection

C. Minimizing Maintenance Cost Through Material Management Systems

D. New Ideas In Material Storage Containers

A. IMPROVED LOCOMOTIVE PRODUCTIVITY THROUGH COMPUTERIZED DATA TRANSFER

While prompt and efficient handling of paperwork is important to all profitable businesses, it is of particular concern to railroad locomotive maintenance operations where the speed of handling renewal parts purchase orders can directly affect maintenance inventories. These inventories, in turn, contribute to the availability and productivity of locomotives.

Locomotive maintenance officers all know that one of the ways to keep locomotives out of the shop and on the road pulling freight is through good renewal parts service. Having material available when needed minimizes locomotive shop time, minimizes idle labor, and is the basis for a smooth running and productive shop. The material managers of the railroad are responsible for providing this service by staging the right parts and other maintenance material at the locomotive shop. They must do this while at the same time minimizing inventory. Striking the right balance between inventory and service level is the "holy grail" of material management. Too much inventory negatively affects the railroad's corporate balance sheet and cash flow equation. On the other hand, locomotives held for material from lack of inventory can result in schedule delays, slow train operations, and can effect the railroad's service level and income.

The amount of inventory needed at a locomotive shop is determined by parts usage, service level, cost, and lead time. This paper focuses on a method to improve lead time with resulting improvements in inventory carrying costs and service level. "Lead time" is defined as the period of time beginning when a railroad recognizes a need for a part to the time in which that part is received at the shop. A major piece of lead time consists of the time needed to request, approve, process and mail purchase orders by the railroad and includes the time taken to handle, edit, and process the purchase order on the part of the railroad's vendor. This total process is known as the primary order cycle and is a major segment of the lead time formula.

For example, a typical railroad purchase order is handled five times by the railroad before it is mailed and four times by a vendor before the order is filled by the vendor. This order may take from four to ten days to work its way through the system before it is fully processed by a parts supplier. This time is reflected in the railroad lead time inventory formula. The cost of handling associated paperwork is substantial and presents an additional opportunity to improve materials department productivity through more efficient systems. Considering the many millions of dollars of inventory held by most railroads, improvement in the order cycle can result in a significant reduction of necessary inventory while maintaining the overall service level.

Recognizing the opportunity that exists in streamlining the order handling procedure, General Electric Company has proposed a new computerized order data transfer system that promises to effectively reduce the order placement cycle by four or five days, eliminate the handling and mailing of purchase orders, eliminate the physical match of invoices and receivers and provide order status on a more timely and less costly basis.

The objective of the proposed system is to enter quotation and

order data into the railroad computer system and General Electric's computer systems once and then transfer those data in computer-intelligible form throughout the order cycle. A secondary objective will be to design a "paperless" system. The degree that this can be done will depend on the procedural, financial, and legal requirements for the system. Specifically, the system will provide computer-to-computer data transfer for the following parts processes:

— Quotations (formal)
— Order entry
— Order changes
— Order status
— Invoicing

Each of these processes will be coded to identify the type of transaction being processed. Computer-to-computer data transfer will be accomplished via a data transition link to a dedicated file space residing on General Electric's computer system in Erie, Pennsylvania. Security checks will be provided to control access to the file. Railroad customers will control sending, retrieval and deletion of their information from the file.

The processing of a parts order will follow this typical sequence of events:

1. The railroad will prepare a computerized purchase order data file utilizing its existing system.

2. The railroad will convert the order data to standard format, combine with other possible transactions, and transmit to a dedicated customer input file on Erie General Electric's computer system.

3. General Electric will off-load the transmitted data from the file each night and enter the information into the order processing system.

4. After processing data transactions, General Electric will transfer the status of these transactions to the dedicated customer output file. Data will be in a standard format and will be segregated by transaction type. Transaction types will include:

— Quotations
— New orders
— Previous orders with open items
— Change orders
— Invoices

These transactions will be available on the file for railroad customer retrieval and processing the morning following the day in which the transaction was made.

5. The customer will control access to the file and retrieval of the information. These daily transaction files must be cleared daily.

6. After the customer has retrieved the information from the file, the data can be selectively entered into the customer's system for further processing and user inquiry.

Quotations and invoices will utilize appropriate segments of this total process.

In addition to computer-to-computer data transfer for quotation and order processing transactions, the system will be designed to pro-

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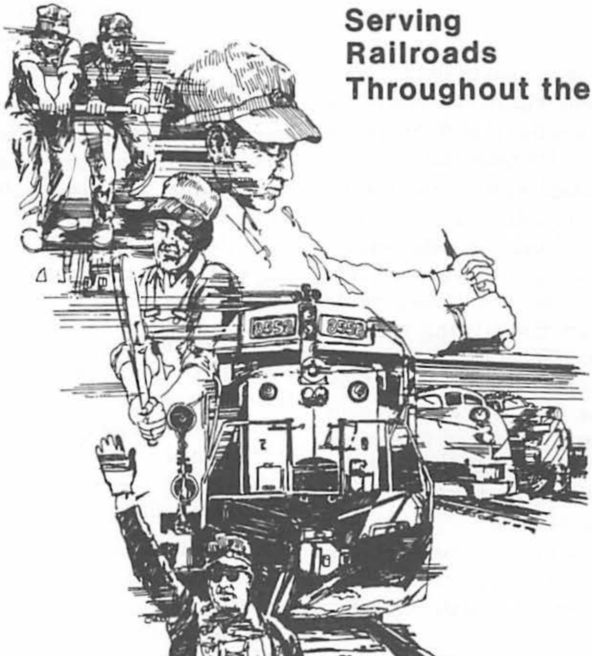

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vide transfer of other General Electric data that are currently provided by General Electric to its customers in a variety of formats. These special transactions will include:

1. Twice monthly transmission of the status of all open orders.
2. Transmission of price data.
3. Superseded parts data.

The system will have routines to verify the accuracy and completeness of these transactions.

The proposed system focuses on improving timeliness, accuracy and efficiency of handling data related to the processing of computer generated quotations and orders while leaving intact the existing railroad customer and General Electric computer systems for processing these transactions. System development will therefore be limited to designing the data transmission and the input and the output interfaces to the existing system.

The following are some of the benefits that are expected to flow from this computer data transfer system:

Reduced Inventory Level
A speeded-up order placement system will take four to five days out of the order placement cycle. This time saving will be reflected in reduced inventory lead times which will result in lower stock levels while keeping service level high.

Greater Accuracy and Control
Ordering errors should be minimized by capturing order data just once during order entry.

Improved People Productivity
Reduction of order handling should enable the purchasing function (and General Electric's order entry function) to improve its productivity. Quick access to the information needed for most orders and inquiries should result in a saving in time and effort for virtually all order placement and order entry activities.

Improved Customer Service
Complete information concerning order status that is readily available on the railroad customer's computer system will assist both the material and mechanical functions on the railroad.

More Dollar Savings
Savings should be realized in labor, file space, keypunching and equipment cost through the simple reduction in the volume of paperwork and through the accompanying reduction in administrative costs.

A functional specification of the direct order entry system has been developed by General Electric, working in cooperation with several major railroads. In fact, this specification provides details for the system just described. With the specification as a guide, design work is now under way to develop a final system that is expected to go on-line by early 1984. It is through this type of innovative and cooperative program that the major railroads and General Electric are advancing the industry in the 1980's and providing real meaning to the 1983 LMOA theme of "Progressing Ideas Through Action".

The committee recommends that the appropriate AAR committees review the future of computerized data transfer and initiate efforts to standardize the formats utilized.

B.
INBOUND MATERIAL INSPECTION

One of the more controversial subjects to face the railroad industry is the question of performing an inbound inspection on material which is purchased from a vendor. Many railroads have become polarized on this subject — primarily due to past experience.

Before a vendor is approved as a source for a locomotive component, the product is generally inspected, torn down, and analyzed closely in the railroad test department. The degree of scrutiny will vary depending on the capability of the test facility. There is generally an interchange of information between railroads, to benefit from testing that has already been accomplished.

If a component is a critical item that could have a catastrophic effect on a locomotive, most railroads will perform a service test. This may also be necessary if conclusive tests cannot be made in the laboratory. The duration of the test will vary depending on the specific component and the length of time needed to produce conclusive results.

After completion of these steps, the product will be approved or rejected depending on the results obtained. If there is still some question as to the adequacy of the product, the railroad may only provide limited approval until further service experience is accumulated.

These steps are standard procedures for most railroads and are generally not subject to dispute. The differences in opinion come after product approval. After a product is approved, some railroads accept the product without further formalized inspection. Other railroads have an in-house quality control group that continues to test the component either individually or on a random basis. It is pertinent to ask why some railroads feel the need to continue testing while others accept the same product without question.

As stated earlier, the degree of testing depends somewhat on past experience. It does not take too many applications of a component that fails prematurely before a railroad reacts. This reaction may be in the form of removing the product from the approved list or instituting inbound inspection procedures to screen defective components before they are applied to a locomotive.

From the railroad viewpoint, the easiest reconciliation of this problem would be for the supply industry to ensure that 100% of its products are without defect. This is a worthwhile goal but one that will be difficult to achieve. Many suppliers have vendors of their own who supply components for the finished product. Even if 100% quality control at the manufacturing plant were assured, this would still

not address the total problem. Much of the damage that occurs can be attributed to the handling and transportation that takes place after the item is produced and tested.

A better grasp of the quality control and inbound inspection question can be obtained by reviewing the advantages and disadvantages.

Advantages

1. An inbound inspection of material will allow identification of defective components before they are applied to a locomotive. This will prevent expending labor unnecessarily and the costly locomotive out-of-service due to defective component replacement. It can also assure that the components in the inventory are usable and not result in a stockout while waiting for a replacement component.

2. The inbound inspection can improve response to correcting problems with defective material. Feedback to the vendor can be provided earlier which will allow him to correct problems in earlier stages of production. If an inbound inspection is not performed, a large quantity of items could be received before it is determined that there is a problem. The correction of the problem would become a much greater task.

3. Warranty recovery can be enhanced through inbound inspection. Defective components can be returned and full warranty recovered more easily. Without inspection, mechanics may be more prone to apply a physically damaged component, especially if they do not have a replacement. The component may operate initially, but fail prematurely and it would be more difficult to assign responsibility for the damage.

4. The inbound inspection places more pressure on the vendor to implement and continue his own quality control inspections. While it may be assumed that vendors strive for high quality, the competitive environment could force a short-sighted vendor into shortcutting quality control procedures. He is less likely to compromise the product if he knows it will be rejected immediately at his expense.

Disadvantages

1. An inbound material inspection is costly to implement and maintain. In addition to the direct labor costs involved, the testing equipment can also be expensive to purchase and operate. Some railroads send inspectors to manufacturers' plants which adds additional expense.

2. It may be impossible to fully qualify a product in an inbound inspection. It is relatively simple to detect physical damage through a visual inspection. However, it is often difficult to determine if an electronic component will operate properly until it is applied to a locomotive.

3. The inbound inspection could result in increased inventories or lead times if components are shipped to a central location for inspection. The delays incurred, in

extreme cases, could result in increased locomotive out-of-service.

Even after reviewing the advantages and disadvantages, it is difficult to categorically agree on the inbound inspection of material. One of the most difficult decisions is on what components should be inspected and which should be excluded. It would be an overwhelming task to provide a 100% inspection on all material that is received. Obviously, you would select components with high failure rates if they are known. Also, you would inspect critical items that could result in locomotive failure and out-of-service in preference to non-critical items. You would also concentrate on new suppliers' products over those vendors with a proven record of high quality. The cost of the product may also be a factor in deciding if it should be inspected.

Following are some examples of items that are currently being inspected and the procedures utilized.

Locomotive Batteries

1. Individual hydrometer readings are made on each cell.
2. Individual voltage cell readings are taken.
3. Terminals are inspected for loose connections.
4. Cases inspected for cracks, broken lugs, and missing cell caps.

Power Assemblies

1. Fork rods and baskets are checked for matched serial numbers.
2. Assemblies checked for loose, missing or damaged dowel pins.
3. Piston cooling passages and mounting bolt holes checked.

Small Electric Motors

1. Armatures checked for free rotation.
2. Brushes and spring tension checked.
3. Megger tests made for grounded circuits.
4. Ohmeter tests made for shorted and open circuits.

While none of these tests is extensive or requires excessive test equipment investment, they have been successful in detecting inferior components prior to application. On other components, or with a more thorough inspection, the investment may be considerably greater.

Railroads that perform inbound inspections increase the cost of the products they purchase by the prorated expense of the inspection. However, this expense can be turned into a saving if they find a sufficient number of defective components. These railroads also provide a service to other railroads that do not perform inbound inspections by forcing vendors to maintain their own quality control procedures.

There has been some interest within the industry in forming a centralized inspection agency, possibly through the AAR, which would perform this service for all railroads and negate this requirement on an individual basis. While

this appears to be a logical approach, there are many obstacles to its implementation. There would have to be agreement on specific inspection standards by all participating railroads.

While no definite conclusions are made in this paper, the committee recommends that each railroad examine its need to implement an inbound material inspection. It is important that a railroad be aware of the condition of material being received. If the percentage of rejected material is significant and corrective steps taken by vendors are inadequate, inbound inspection may be warranted.

C.

MINIMIZING MAINTENANCE COST THROUGH MATERIAL MANAGEMENT SYSTEMS

Material management systems, including material accounting, may seem like a strange topic to be presented to a group of locomotive maintenance officers, but you can be assured that there are many ways you can help reduce not only your maintenance cost but, also material handling cost. At one time or another every piece of locomotive material handled by material management must also be handled by a mechanic.

With any material management system there are many areas that we must all look at in order to reduce cost. It makes no difference if we are in mechanical or material management, we must cooperate with each other to see that costs are kept at a minimum. Each of two departments may have its own operating budget, but we cannot let one department's costs be optimized at the expense of the other. Since every piece of material must be handled by both departments, we must see that the two operations compliment each other.

As we all know, there is more to the cost of material than just the invoice price.

First, there are the cash dollars tied up in inventory. This is cash that is not at work — it's earning nothing. If it were invested today it would be earning 10%, and not too long ago 18%. What railroad today would not want to be turning 10% of its gross to net profit? Each of us must do all we can to keep inventory levels as low as practical. The total dollar level of the material inventory stays under close scrutiny by all railroad top management and you can rest assured that the material management department hears from them when figures begin to creep up or rise to unacceptable levels.

Second, there is the physical cost of maintaining, handling and housing the inventory. This cost has always been debatable, but certainly must be in the area of 10%.

Third, there are waste, spills, obsolescence, deterioration and pilferage which still further increase costs.

These costs, regardless of which category they fall into, end up being a part of operating expense. This makes it of interest to all of

us. A very fine line must be walked in both mechanical and material management departments. The fine line is having exactly what's needed, when it's needed, and having personnel at the right location and time to repair a locomotive with a minimum of down time, or to catch it before it happens. Either side of this fine line is the cost of having items in inventory not being used, and in the opposite case, the cost of not having the item when needed to make a repair.

We can all agree that we must deal with reality and recognize that few railroads today can afford to meet every material need whenever and wherever it might occur. We will continue to see locomotives towed in and material flown in to make the necessary repairs.

Let's look at some material handling systems and point out what this committee feels are their advantages and disadvantages:

A. Distribution Center System

The basic philosophy of this system is for purchasing to buy for the distribution center, and storehouses and maintenance facilities to be supplied from the center. The method of expensing or charging out this material on any particular railroad may vary, depending upon our accounting and audit people. Most railroad accounting and audit departments will allow for shipments of material to small running repair facilities, or simply an engine terminal to be expensed direct when shipped. Normally though, where a distribution center concept is used, the basis has been laid for the collection of data which will allow accumulation of information that will record the movement and application of an individual piece of material to a locomotive. This system requires records of the transfer of material from the distribution center to a regional or locomotive repair shop storehouse. Materials are then issued on an individual requisition basis to a mechanic as he arrives at an issue window, or it may be delivered to the mechanic at his work site. In either case, records can be kept of application of an individual piece of material to a particular locomotive. This record must originate from the user.

This type of material system has several advantages and disadvantages:

Advantages:

1. Purchasing simply for a distribution center enhances the ability of the purchasing department to buy in more economic quantities.

2. As records of all movements of material are kept, you are able to compile complete usage data, right down to locomotive application.

3. With material under control in a separate housing or storage facility, the major part of the inventory is inaccessible to pilferage and theft.

4. With material stored outside the shop or mechanic's work location, you can have a cleaner, uncluttered maintenance facility.

5. With inventory housed in separate facilities, material management finds it easier to compile inventories, and there is less mixing of material in bins. Components are not robbed when mechanics can't find an individual piece needed.

6. Probably most advantageous to the mechanical department is the ability to develop complete accountability for use of material and its application. In addition, material is not expensed until applied.

Disadvantages:

1. This system will probably increase inventory levels as the distribution center is really nothing more than a backup supply of material. The regional storehouse, engine terminals and running repair points are operating off their own inventories.

2. Mechanical forces will lose time either ordering, securing, requesting, going for, or waiting for delivery of parts needed.

3. Freight costs are higher due to reshipment of most material, with additional equipment involved in its distribution.

4. Generally this system requires more people in both mechanical and material management.

B. Semi-Distribution System

This system would have a district or regional material management facility at a major locomotive, car or maintenance of way facility. Each of these regions or districts would deal direct with Purchasing without going through a distribution center for its material requirements. Outlying engine terminals or servicing facilities would have a limited number of items that would be handled through the region or district storehouse. Items such as traction motors, auxiliary generators, heads, pistons, liners and compressors would fall into this category. Requirements for other materials would be requisitioned through the district or region and handled with purchasing for direct shipment from supplier. Items of a supply type could be contracted for locally. All materials distributed to outlying inspection points and engine servicing terminals could be expensed as shipped unless it is the desire of the mechanical department to issue requisitions for material in order to account for its application.

This material management system has a large degree of flexibility in its operation, as it could allow for both chargeout as purchased or chargeout as used with reporting by the mechanical department, or could be expensed on a monthly inventory basis. The monthly inventory approach would not allow for accountability of use or application, as there would be no reporting of use by the mechanical department as material was applied. This system could also allow for placing of expensed items in the shop for the use of mechanics on the job site. High dollar, high volume items would be drawn by requisition from the storehouse and, if required, a delivery system would be set up.

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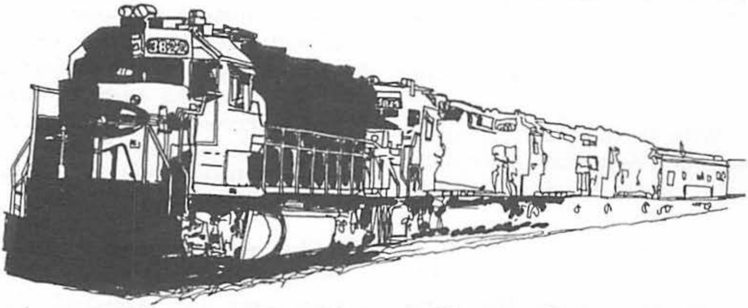

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Advantages:

1. Better inventory management, as the material at any given location would probably be consumed at that location. You would not have sitting in a distribution center material that would be used at some point perhaps a thousand miles away.

2. With the districts or regions feeding into centralized purchasing you still get the benefit of quantity buying.

3. Moving into the shop of expensed small items, which could be as much as 75% of the items, would help keep the mechanic on the job.

4. You do enjoy some degree of control of expenses and record of applications, as in most any locomotive maintenance operation 10% to 15% of the items will account for 80% to 85% of the dollar value.

5. Can be accomplished with fewer people.

Disadvantages:

1. For that material which is expensed as purchased, the mechanical department will lose control of accountability and application of its use.

2. Placing materials openly in the shops makes you more accessible to pilferage or theft.

3. Unless you have a shop designed and constructed to accommodate material at the job site, you can find floor space a problem. You may not be able in every instance to locate the material where you want it.

4. Placing materials at shop locations and asking mechanical forces to write requisitions for its use has not proved successful. Periodic checks have revealed that in many instances materials are used and mechanics either are too busy or simply forget to record its use. In situations such as these, forced chargeout must be made due to inventory deficits. These could hit your budget at an inappropriate time.

C. Charge-Out System

In this material management system every item of material possible is placed in the shop at a spot most accessible to the point of use. The committee found one railroad where fully 95% of all material was in the work area. Only such large components as batteries, compressors, radiators, power assemblies, locomotive air brake sets, high voltage cabinets, etc., would not be stored in the work area. Items such as these would be located in close-by storage areas.

All items of material are expensed at time of purchase except for certain high-dollar, high volume usage items. The latter are expensed on a monthly basis by taking physical inventory and making a monthly charge. Examples would be locomotive wheels, gears, pinions, axles, heads, pistons and liners, with high volume items being exhaust valves, air bag filters, lube oil filters and even brake shoes.

No record is kept by the mechanical department as to the use

of an item from an inventory standpoint. To put it fairly bluntly, the mechanical department budget is basically controlled by material management, and material management's ability to get prompt invoicing, since the invoice is the charge document.

To dispel any misconception, it must be understood that, when material is first moved into the shop, it is not expensed. Based on min/max levels and predetermined physical inventories, the replacement material is that which gets expensed. In effect, the using department is paying for that which it just used when material is expensed from invoice.

With established min/max levels assigned to each item and a physical count entered into data equipment, an automatic computer purchase order is generated when inventory level drops below min. Each item of material in the shop is precoded in the computer with an expense code number that is part of its description. Therefore, this information appears on the purchase order and no information is required from the mechanical department to accomplish correct accounting for chargeout.

Advantages:

1. Allows for handling of material one time to point of use.

2. Makes possible individual work bench assignments with the materials necessary for the mechanic's work placed right at his finger tips.

3. After handling of invoices there are no other paper transactions to record usage of material.

4. Once shop items are expensed, you take a complete inventory only once a year to determine present value of inventory. Debit or credit is made to expenses, depending upon this value as it relates to previous year's inventory level.

5. Can be accomplished with fewer people, both mechanical and material management.

Disadvantages:

1. Unless it's a new building designed for handling inventory in the shop, location of material can be a problem.

2. Housekeeping - materials mixed in bins.

3. Robbed components.

4. Even though you have an idea of the dollar level of base inventory, in a year's time it can change substantially due to a high rate of inflation or the addition of new items due to locomotive changes.

5. Since individual shop requisitions are not written, you lose the ability to record repair items to a particular locomotive or machine.

Today, everyone is aware of the high costs of operation, and each of us must make every effort to reduce these costs. From a materials standpoint (and forgetting about when and how charges are made to expenses), we must remember that when we buy material the cash is gone. In essence, if you do expense an item and, at the annual inventory it's still on

the shelf, you must take it back into the general ledger or material balance.

From a material management or material handling standpoint, there are many areas where locomotive maintenance officers can be of help in reducing costs as they relate to value of inventories:

1. If you have locomotives of more than one manufacture, try to concentrate maintenance of a particular make at one location. As an example, if GE represents 20% of your fleet, attempt to route this power so that scheduled maintenance can be performed at one shop.

2. Develop system shops for repairs to components, such as locomotive air brakes, governors, engine blowers, power assemblies. This requires maintenance parts to be carried only in one shop.

3. If possible, arrange the budgeting process so that the component repair point is totally responsible for system expense of the repaired item. The backup supply of any new part to be added to the repair pool should be furnished by the repair point and be a part of its expense. In other words, if the repair point can't furnish a repaired item, then it must furnish a new one. While records could be kept of the movement of parts, debits and credits to individual shop budgets could be avoided and this eliminates paper work.

While there are many, many areas that could be enumerated, these few reduce your cost, cut down on paper transactions and reduce transfers in the accounts. They also have a tremendous bearing on reduction of inventories as in most instances they put repair parts at only one location on your railroad.

D.

NEW IDEAS IN MATERIAL STORAGE CONTAINERS

The 1982 Diesel Material Control Committee presentation included a paper entitled "Maintaining Product Quality Through Use Of Shipping Containers". The committee felt that a natural extension of this subject would be a paper on the use and benefits of storage containers. In many cases, storage containers are exactly the same as the shipping containers presented in the 1982 paper. The savings used to justify the shipping containers can also be applied to the storage containers. However, the benefits of storage containers for the efficient supply of material within a shop can be much broader.

The primary purpose of storage containers is to function as the intermediate staging area between the delivery and end use of material. This is applicable both in the material department warehouse and the mechanical department shop floor. The effectiveness of the storage container can significantly impact the efficiency of both departments.

It may be beneficial to provide a better definition of a storage con-

tainer. The most common storage containers are shelves, bins, and pallet racks. These provide a designated location to segregate and store items of material ranging from nuts and bolts to relatively large locomotive components. Almost all material warehouses have a large assortment of these types of containers. The use of storage containers in locomotive repair facilities is generally much less.

Other examples are storage containers designed to hold specific locomotive components. These containers may hold multiple components such as modules or pumps or single components like air compressors or generators.

It is obvious that the construction or purchase of storage containers represents an expense that must be offset by associated benefits. Some of these benefits are listed below:

- Safety
- Productivity
- Inventory control
- Damage prevention
- Area utilization

The safety benefits are derived primarily from having material stored in a manner that will prevent it from falling. The storage containers can provide an organized, uncluttered shop area which has been proven to contribute to safety as well as improved attitude. The elimination of having to crawl over material to get to the needed part will definitely minimize the safety risk. Storage containers designed to be handled by fork lift trucks or overhead cranes can also reduce the material handling risk.

Productivity improvements achieved through the use of storage containers can more than justify the expenses of implementation. It may be simple to deliver material to a shop repair location and set it on the floor; however, the time a mechanic loses searching for a specific item reduces productivity. The advantage of the storage container is that it is stocked in advance and the mechanic knows exactly where to go to obtain a specific component. The storage containers can be placed adjacent to the work area that the material is serving, which will reduce the distance the mechanic must travel.

This saving is generally easy to quantify. An example might be that a mechanic must obtain a specific item ten times each day. By the time he leaves his work area, selects the item and returns, he may lose three minutes during each trip. The annual saving by providing a storage container adjacent to his work area would be:

Saving = 10 trips X 3 min. trip X $12.70/hr X 250 days year ÷ 60 = $1,587.50 per year.

A $1,587.50 investment in an efficient storage container would be justified to eliminate this productivity loss and produce a one year return on investment. If ten mechanics are affected and a three year return on investment is satisfactory, the justified expenditure would approach $50,000. In many cases, the larger productivity improvements have already been made and it is important for a good manager to concentrate on the three-minute savings. In the example cited, the reduction of this lost productivity would save 125 manhours per year for one man or produce a 6.25% improvement. An intangible benefit is the reduction in employee fatigue.

The use of storage containers can also result in improved inventory control. With the material both organized and segregated, it is easier for the material or mechanical department to determine the quantity of material on hand. If the inventory must be physically counted periodically, the containers can result in reduced inventory expense and labor effort. It is also easier for personnel to determine when inventories are low and must be replenished. This can prevent delays that may occur due to running out of material.

Damage prevention is also a real benefit that may be achieved through use of storage containers. Specialized containers for components can be designed to prevent components from hitting each other during handling and storage.

Finally, area utilization can definitely be improved by use of storage containers. The use of shelving, bins, and pallet racks allows verticle storage which lessens the consumption of floor area. Individual containers can also be designed to stack, which provides a secure method of storage. While there may be some facilities with a surplus of floor space, most mechanical and material departments find floor area at a premium. If you were constructing a new facility, you would design it to economize on non-productive space needed for material storage. With a conservative cost of shop floor area at $50 per square foot, this thinking would be mandatory. While an existing shop does not require this expenditure, the value of the floor areas is just as important to accommodate increased production capabilities or plant expansions. Again, this saving can be quantified in an example of three 4' X 4' pallets being placed in stackable storage containers or placed on pallet racks. Saving = (3 pallets X 16 sq. ft. - 1 pallet X 16 sq. ft.) X $50 sq. ft. = $1,600.

This example would have a one time saving of $1,600 in reduced building construction cost or value of area made available for productive use. This saving can be multiplied by the number of pallet racks that can be stored vertically. There is also a continuing operating expense saving that can be made through reduced heating, lighting and taxes.

The benefits indicated can result in both quantified and intangible savings. All are important in designing a storage container system.

Several factors must be considered in designing storage containers. Shelving, bins and pallet racks are available in various sizes, although most railroads have adopted standard sizes and designs. They must be capable of supporting the size and weight of components that are required.

Specialized storage containers must also be appropriately designed. The use of the same container for both storage and shipping will reduce expense of building, inventory of containers, and the need to transfer material from one container to another. It may be possible to adapt storage containers for various components which would further enhance these savings. Storage containers should be designed to stack to reduce floor area requirements as discussed before. The containers should have the capability of being handled by either fork lift or overhead crane for optimum flexibility.

The sophistication of storage containers depends on imagination. One railroad utilizes a "Ferris wheel" type of container for storage of power assembly components. This allows storage of components in a higher rack than could normally be used. The chain-driven elevator can be indexed to remove a specific component that is segregated by size and type. An enhancement of this system automatically counts and maintains an inventory of components in the rack as they are added or removed.

The theory and benefits of using storage containers has been presented. It can be stated that all railroads use storage containers to some degree. They may be in the simplest form of shelving or a sophisticated system such as the rotating power assembly component system just described. Following are some examples of storage containers that have been used by some railroads for many years with positive success.

Main Generators

Due to the size and shape of main generators, a storage container can be very beneficial. It will keep the generator off the floor and will also minimize damage due to striking other components. In most designs, an I-beam frame supports the generator base and an upright at one end is used for the shaft and bearing support. Mounting bolts are used to secure the generator or alternator to the skid.

Traction Motors

While traction motor frames are relatively damage-proof, the gear case support arm and traction motor leads are susceptible to damage if some precautions are not taken. Also, traction motors sitting on the floor may incur moisture damage when adjacent floor areas are washed. One railroad has converted surplus auto parts racks for the storage and shipment of traction motors. The use of a surplus rack for this dual purpose container reduced the initial cost by not having to construct or purchase specially built containers. Any traction motor can be placed in the container which has three vertical corner legs. The fourth leg was removed to facilitate loading and unloading. A hinged top bar allows securement of the traction motor in the container if necessary.

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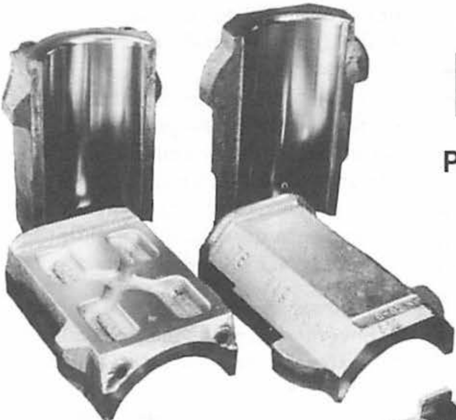

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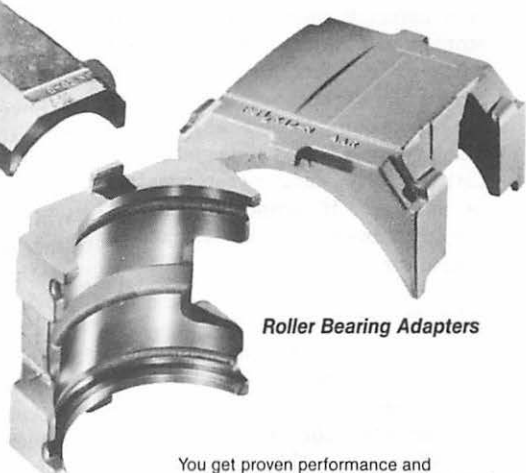

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Auxiliary Generators

Storage containers are currently used for auxiliary generators with and without blowers. One style is a flat metal skid with a raised pedestal to accommodate the various mounting arrangements. Another design utilizes structural members for the generator and blower securement.

Turbochargers

The high value of turbochargers is a primary reason for providing storage containers. A metal skid with raised sections is used to mount the turbocharger in its running position. Either a metal or plastic cover can be used to protect the turbocharger from weather or damage. If properly designed, the containers can be stacked if necessary.

EMD Power Assemblies

Dual purpose storage and shipping containers are used for EMD power assemblies. This container can be used for shipping the assemblies from the central repair facility to outlying locations that replace assemblies. The containers are used for storage until the assemblies are needed and then used to store and transport the removed assemblies back to the repair facility. This is the ultimate utilization of a storage/shipping container. One railroad uses an angle iron frame with steel tubes to hold eight complete assemblies with rods. Both fork lift pockets and lifting eyes are used for moving the container. The power assemblies are wrapped in plastic for protection.

Several other railroads use the same principal without the tubes. An angle iron frame holds eight power assemblies in position - generally four fork rod and four blade rod assemblies.

If the container is not transported between shops, it may be beneficial to have smaller containers or brackets to contain injectors, rocker arms, and other necessary components used in the installation of the power assembly.

GE Power Assemblies

Several railroads have combination storage and shipping containers for GE power assemblies. One uses a container for four assemblies which is a low profile design. The liner sits in a recessed hole at each of the four corners with a center upright with a lifting eye used to lift the container with an overhead crane. Pockets are also provided for fork lift movement.

Another railroad uses a similar principle but only holds two GE power assemblies. Fork lift pockets are used for movement of the container.

While GE assemblies can also be stored flat using a pedestal to support the rod, this method does consume more floor space.

Engine Governors

Several railroads use governor storage containers due to the need to protect this component. The general design is an enclosed container with the governor fastened to a removable base plate. One rail-

road uses a clamshell door on the top to remove the governor vertically while another railroad has a side entry door with the governor and base plate on slide rails for loading and unloading. While the enclosed container is only necessary when using this as a shipping container, it may be practical to use in shop storage also to prevent possible damage.

Governor Power Pack

One railroad uses a metal box for storage of governor packs. The top half of the metal container lifts off for ease of access. Two power packs can be carried in the container at one time and it is equipped with steel pegs to secure them in position. If this container is only used for storage, it may be appropriate to design a larger container to contain additional power packs.

Radiators

One design of a storage container for radiator cores is a box design with four cores placed vertically in pockets which are sectioned off. The tight clearances prevent the cores from moving in the pockets to help reduce the possibility of damage in transit or storage. The box containers are stackable to reduce storage space requirements.

Assembled radiator banks can also be stored using a longer version of the metal storage container. The enclosed container ensures no damage to the fins.

Lube oil coolers can be stored vertically, two per container, by bolting to the flat metal skid.

Air Compressors

Several variations of air compressor storage containers are available. One railroad converted four-sided metal skids and provided securement bolts to hold the air compressors in position. Another railroad has used flat metal containers with various bolt hole patterns which will allow shipping any type compressor. Fork lift pockets are provided to transport the compressor to the work area. Due to the small base size of the air compressor, a storage container similar to these will allow the compressor to sit on the floor without risk of being knocked over.

In conjunction with air compressors, metal four-sided skids have been converted for shipping air compressor heads, six to a skid. Clamshell doors were provided and wrapping the heads in plastic prevents weather deterioration in shipping or storage.

Cooling Fans

One style storage container was constructed by modifying a surplus auto parts shipping rack. Two 36" or 48" cooling fans and motors can be stored, one above the other, in the open container which has four vertical legs and cross pieces to support the lip of the fan. Dowel pins hold the cooling fans in position. Another version is used for storage of one cooling fan in a similar type container.

Locomotive Batteries

While it is not necessary for unitized batteries, at least one railroad uses a metal storage container for monoblock batteries. Each container will hold four batteries with fork lift pockets located in the base of the container. Sides on the container prevent the batteries from shifting or falling off.

Hyatt Journal Bearing Boxes

One railroad has a novel shipping and storage container used for Hyatt journal bearing boxes. Each container holds four journal boxes. The bottom of the container has rollers and the container is injected in the production line conveyor system so that the box is loaded as the last step. Boxes being returned for repair are also placed in the conveyor line and rolled out of the container onto the inbound conveyor. This container is used for storage, shipping, and as an integral part of the conveyor line.

Water and Lube Oil Pumps

Smaller components such as water pumps and lube oil pumps. can easily be stored in section containers. By sectioning the container, the components do not strike each other while having the advantage of multiple storage. While this container is used specifically for shipping, the same or a larger container could be used for storage.

EMD Modules

At least one railroad uses enclosed boxes for storing and shipping six EMD modules to a central repair point. A hinged lid is used for access and the modules are placed in slots positioned face up. Another module container is color coded for storage and shipment of bad order modules due to the difficulty of differentiating between good and defective modules visually. Module containers can be padded to protect from shock or impact in handling. An alternative method is a shelf type rack which can hold individual modules. It is important that the contact pins and the electronic components in the module be protected.

These examples of storage containers in use today indicate some of the possibilities for major locomotive components. Most of these containers satisfy the need for a combination shipping and storage container. Many are stackable or could be easily modified to provide this feature. All of the containers provide a degree of protection not afforded to components that are placed on the floor.

While not presented in this paper, storage containers can also be designed for tools used by mechanics in their work area.

The committee recommends that railroads investigate the benefits that are attainable through the use of storage containers. If components are shipped between repair facilities, shipping and storage containers should be investigated as a system that will satisfy both requirements.

DIESEL MATERIAL CONTROL COMMITTEE

Five-Year Index

1982

Maintaining Product Quality Through Improved Material Handling

1. Use of kits in locomotive maintenance
2. Cost effective methods of shipping material from vendors
3. Union Pacific's Component Inventory Maintenance System (CIMS)
4. Advantages of using shipping containers

1981

Diesel Material Control: Innovations In Material Handling and Control

1. Disposal of Unserviceable Component Parts: What is the Most Profitable Method?
2. Innovations in Stores Material Handling, Via Computer Technology
3. Locomotives Held for Material: An Update for the 80's
4. The Best Approach to Procuring Material; New, UTEX, Repair and Return or Shop Repair

1980

Locomotive Material Management: What Lies Ahead in the 80's?

1. Robbing Material — Its Consequences to the Railroad
2. Cyclical and Seasonal Demand for Material — Some Counteractive Methods
3. Improved Mechanical Department and Material Department Communications — One Step to More Efficient Locomotive Maintenance
4. Uses and Service Life of Reclaimed Power Assembly Components

1979

Material Management: Dollars Saved Through Efficiency

1. Investment and Cost of Carrying Inventory — 1979 (A Comparison with the Committee's 1973 Study)
2. Dollars Saved Through Advanced Inventory Control Systems, Via Increased Availability

1978

Problem Solving Through Analysis and Projection

1. Warranty Labels and Their Use
2. Economics of Rebuilt Components
3. What Have We Learned From the 1975 Material Crisis?
4. Locomotives Held for Material
5. Computerized Information Systems

J. J. BUTLER
Chief Mechanical Officer
Consolidated Rail Corporation
Philadelphia, PA 19104

LMOA wishes to express its thanks to Consolidated Rail Corporation for again hosting Pre-Convention Presentation in the Altoona area.

Our Shop Equipment Committee's presentation was well received in what we trust was a mutually beneficial experience.

Our thanks again to Jim Butler and his forces at Altoona Shops.

Tuesday, September 20, 1983

10:30 A.M.

REPORT OF THE COMMITTEE ON SHOP EQUIPMENT

Pre-Convention Presentation: Consolidated Rail Corporation

April 19, 1983
Sheraton Motor Inn
Altoona, PA

P. F. HOERATH, Chairman
Superintendent Plant Engineering
Consolidated Rail Corporation
Altoona, PA

VICE CHAIRMAN

J. R. Snowden, Shop Engineer, Illinois Central Gulf Railroad, Paducah, KY

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1983 TOPIC:

"TRAINING AND TOOLS WILL DO THE JOB"

PERSONAL HISTORY

PAUL F. HOERATH

Paul F. Hoerath was born in Cheswick, Pennsylvania, July 12, 1926. He attended Mt. Lebanon Public Schools, graduating from High School in June 1944. After graduation, Paul went into the Army Air Force Aviation Cadet Program, being discharged in October 1945. He attended Carnegie Institute of Technology (now Carnegie Mellon University) graduating in June 1949 with the degree of Bachelor of Science in Mechanical Engineering.

He began work for the Pennsylvania Railroad in the Special Apprentice Program, later changed to Junior Engineer, completing that course in 1952. This training included work on steam and Diesel locomotives at Pitcairn Enginehouse; Diesel locomotive, freight and passenger car work at Altoona Shops; work at Harrisburg and Enola Diesel Shops; Sunnyside Passenger Yard and Maintenance of Power Equipment in the New York Station and Tunnels; work on self-propelled electric multiple unit passenger cars at Paoli Car Shop; and ended up the program with training on Electric locomotive repair at Wilmington Shop in Delaware.

Paul was then assigned as a Gang Foreman at 28th Street Enginehouse at Pittsburgh, PA, supervising employees dispatching diesel and steam locomotives for passenger trains, finally ending up supervising workers on monthly inspection and repair of Diesel locomotives. He was transferred to Altoona Shops as Assistant General Foreman, Methods and Cost Control, then moved on to Camden (New Jersey) Enginehouse as Assistant Enginehouse Foreman. He then was transferred to Philadelphia Region as an Engineer, Methods and Cost Control and thereafter, was sent to Louisville, Kentucky as Motive Power Foreman. Assignments of Assistant Master Mechanic at Conway and Altoona followed. Next, he was appointed Master Mechanic at Canton, Ohio, Master Mechanic at Pittsburgh and then Master Mechanic at Philadelphia, where he also became Chief Mechanical Officer of the PA-Reading Seashore Lines. Paul was transferred to Chicago as Assistant Regional Mechanical Officer and while in this position, became Pennsylvania Railroad's representative to the Shop Committee, L. M. O. A. After merger of Penn Central, the New York representative became the representative for Penn Central on the Shop Committee with Paul returning to the Shop Committee upon Al Smith's retirement. Paul was transferred from Chicago to Cleveland as Assistant Regional Mechanical Officer and in 1970 was appointed Superintendent Plant Maintenance at Altoona Shops. In 1980, he became Superintendent Plant Engineering.

He is a member of Pi Tau Sigma National Honorary Engineering Society; Dormant Lodge No. 684 F. & A. M., Altoona Consistry and

Syria Temple; Life Member National Rifle Association and a member of Blair County Game Fish and Forestry Association.

His hobbies are hunting, skiing and exploring the old roads and trails by Jeep through the forests and mountains surrounding Altoona.

Paul married the former Clarice Chalfant on September 2, 1950, and they have four children; Celia in West Chicago, Illinois with grandchildren Dana and Charles; Mark and wife Karen in Cleveland, Ohio; John living at home while attending Penn State University; and Kurt in U. S. Navy Electronics School at Great Lakes, Illinois.

INTRODUCTION

The past year's economic effect on the railroads has been felt throughout the industry with general business activity considerably reduced and the great capacity of the railroads only partially used. With recovery, business is on the increase and railroads are again very active in pursuing the ways and means of making improvements.

Our Shop Committee Paper "Training and Tools Will Do the Job" addresses areas that can be changed to cut expenditures, improve quality and increase output. The following subjects are included:

A. Locomotive Maintenance Using a Production Line Process
B. Railroad Shop Tools to Increase Productivity and Improve Quality
C. Dynamic On-Line Performance of Locomotives without On-Board Telemetering
D. Management in Action
E. New General Electric Training Center
F. Welding Qualifications

A.
LOCOMOTIVE MAINTENANCE USING A PRODUCTION LINE PROCESS

One railroad uses a production line process to maintain its locomotives. Locomotives are moved along a maintenance line, stopping at eight different spots. Certain items of maintenance and repair are assigned to each spot.

A computer is used to store and furnish information on all locomotives. A CRTerminal and printer are located in a tower office which is manned by a company official around the clock. The tower operator receives calls from everyone experiencing trouble with the operation of locomotives and enters the information into the computer. The computer furnishes the operator with a history on each locomotive as well as location of locomotives — whether they are in the shop or on line-of-road. Supervisors have a CRTerminal and printer in the shop so that they can be aware ahead of time of what work will be required on locomotives when they arrive at the shop. They feed reports of work performed into the computer.

The tower operator also keeps a color-coded magnetic locomotive identification board current so that he can tell at a glance where all locomotives within the shop are located as well as in which master mechanic territory locomotives are located. He keeps up with locomotive maintenance due dates, and communicates with personnel at various points on the railroad to arrange for locomotives due maintenance or needing repairs to come to the shop.

Locomotives due maintenance are placed on the maintenance line outside spot one. While still running, each locomotive is inspected for air, water and oil leaks. Operation of sanding systems, air brake systems, horns and crossing bells is checked. Magnetic tapes are removed from speed recorders and train handling recorders and sent to the test laboratory along with lube oil, air compressor oil and cooling water samples for analysis. Lab personnel advise the shop tower if tapes do not play back properly which may indicate locomotive speed recording equipment may not be operating properly. It is also reported if the lube oil or air compressor oil is found to be contaminated, and recommendations for correction of problems are made. A solu-bridge is used at spot one to determine the quantity of treatment to be added to cooling water. This quantity is written on the tag of the sample bottle that goes to the lab. If lab tests indicate a different quantity should be added, shop personnel are advised.

As locomotives are moved inside to spot one, each tread of each wheel is inspected through one complete revolution to determine if the wheel needs to be machined.

Spot one is equipped with forms cabinets having a slot assigned to each locomotive. While locomotives are on line-of-road, paperwork concerning each is put into its slot. Paperwork includes inspection reports sent in by line-of-road personnel, computer reports giving information on time-regulated items and instructions and sketches on projects to be performed. When a locomotive arrives for maintenance, its paperwork is put onto a clipboard along with a set of craft-color-coded forms listing each scheduled maintenance operation to be performed throughout the maintenance line process. The clipboard travels throughout the process on the seat of the locomotive. As each operation is completed, the man performing the work signs the proper forms.

Ramps are located at the level of locomotive running boards. The ramps are split into sections that can be folded back to give access to locomotive side compartments. Pits are located on the outside of rails and between rails for access to truck sides and undersides.

Inspection is completed on each locomotive. A hydraulic-operated device is used to bar EMD engines over for inspection of cylinder walls, pistons, rings and crankcase components. Batteries are serviced, electrical equipment is cleaned and electrical systems are checked. Traction motor brushes are changed

out when needed. Traction motor wheel assemblies are lubricated. Brake shoes are changed out when needed. Lube oil, fuel oil, air and air compressor filters are changed out. Lube oil strainers are cleaned.

At spot two, locomotives are cleaned from the running board upward utilizing ramps. Detergent is received in tank cars and stored in a tank. It is automatically mixed with water to the proper concentration and stored in a heated vat. Rinse water is pumped through an instant-heating, gas-fired water heater.

Engine compartment doors are opened; the engine and compartment are sprayed with the detergent-water mixture and rinsed with high-pressure hot water. Doors are closed and all exterior surfaces are sprayed and rinsed. Debris is removed. Cab interiors and toilet compartments are cleaned. Toilet bowls are scrubbed with a special toilet detergent and rinsed with hi-pressure hot water.

It has been determined through reports and inspections whether a locomotive requires use of the drop table inside the main shop. At spot three, the maintenance line splits into two tracks, one of which goes over the drop table; therefore, the track switch has to be set in the correct position before moving a locomotive to spot three.

A locomotive is moved from spot two outside to spot three; it passes through a high-pressure cold water carbody rinse spray system. Just before a locomotive enters the rinse, the locomotive operator turns on the pump with a radio-signal, push-button control he carries with him. Immediately after leaving the rinse, he turns off the pump, thus conserving water.

At spot three, locomotives are washed from the running board downward. A mobile, air-operated truck washer is located on each side of the track. They are located so that trucks can be washed on either track. When a locomotive operator spots a locomotive, he pushes a button furnishing air and high-pressure cold water to the truck washers. Each truck washer is driven on its track along the locomotive by an air motor. Another air motor drives an eccentric which moves a water nozzle up and down. Timers stop the truck washers after they have made three passes by trucks.

At spot four, fuel and sand are added to the locomotive. Operation of mechanical and electrical devices and speed equipment is checked. Speed indicators are calibrated. A load test is made. A ramp above the track provides a safe, convenient means for inspecting cooling fans.

Spot five, which is the first spot inside the main shop building, is equipped with ramps, pits, jib cranes and an overhead crane. Repairs are made to correct problems reported by line-of-road personnel or found during maintenance line inspections. Air brake components are changed out when due or bad-order. Brushes are changed out on electrical rotating equipment

when needed. Various oils, grease and cooling water are added when needed. Facilities for the retention of lube oil and cooling water are available. The cooling water system includes equipment for automatically analyzing cooling water and adding water treatment as required. Welders and special tools are located conveniently.

Spot six is equipped with ramps, pits and overhead crane. One of the two tracks goes over a drop table capable of handling a complete truck. Two air-operated rams (one located on each side of the track) hold up the end of the locomotives on the drop table. The traction motor or truck to be removed is disconnected, and a four-screw drop table lowers it and moves it to an open pit. The overhead crane transports the bad-order part to a designated area and transports a good part from a storage area to the drop table. The drop table moves the part under the locomotive and raises it into position for reconnection.

Spot seven is the location for coupler, yoke and draft gear work. Also, all other remaining work is performed. This spot is equipped with a ramp and an overhead crane.

Spot eight is equipped with a ramp. All work is inspected. Each locomotive is checked for cleanliness. Electrical and mechanical operational tests are performed, and equipment protection devices are checked. A brake test is made, and operation of the emergency brake valve is checked.

Locomotives having certain new or repaired parts applied or having certain problems corrected are moved outside the main shop and load tested. This location is equipped with an external load box for locomotives not equipped with self-load. To check certain work, locomotives are given a road test on a track adjacent to the shop.

Locomotives having wheels requiring machining are switched and spotted on the wheel truing machine. When more than one set of wheels on a locomotive has to be turned, a winch mounted at the wheel truing machine is used to spot locomotives for other wheel sets.

When maintenance on a locomotive has been completed, a super visor checks the cab card and air card and signs them when required. He checks, signs and dates all paperwork and turns it in to the maintenance control office where a file is kept on each locomotive. A log book on projects is kept current in the office.

Materials and tools needed at each spot on the production line process are located conveniently to work locations. All bad-order materials are placed in designated areas. Repairable parts are picked up from designated areas by purchasing department personnel and delivered or shipped to repair points. New and repaired parts are set up on a maximum/minimum ordering system. Purchasing department personnel count all parts periodically. If the number of parts is below the minimum quantity,

enough parts are ordered to reach the maximum quantity. When parts are received, purchasing department personnel put them in their designated areas.

Personnel responsible for cleaning shop floors, ramps and equipment are assigned to certain areas of the maintenance line.

Each person assigned to any maintenance line function as well as any other function at the shop is instructed by management on the importance of safety in every move made. Safety rules are explained. A shop safety manual and all necessary safety equipment are issued.

B. RAILROAD SHOP TOOLS TO INCREASE PRODUCTIVITY AND IMPROVE QUALITY

Tame and Proceco are two companies that manufacture special tools to do locomotive shop jobs peculiar to locomotive components.

They are rugged and built to do the job using less time and manpower.

Tame Model 86 Water Pump Repair Console

This unit consists of a work bench with all the necessary pullers and presses to strip and/or build EMD type water pumps.

An air powered positioner will rotate the pump 360° to any position necessary for removal or application of component parts.

Counter balanced 3 jaw hydraulic pullers can easily be pulled down into position for removal of gear and impeller.

A hydraulic press for shaft removal is located on the right side of bench with adapters that will not damage the seal.

With the adapters that come with the console and a few hand tools, repair can be accomplished without the mechanic leaving the bench.

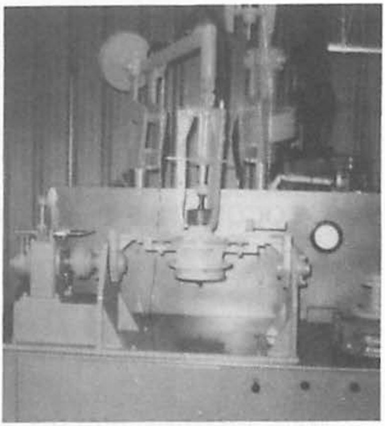


Photo 1

A supply of compressed air at 90 lbs. pressure powers the console.

Tame Model 87 Lube Oil Pump Repair Console

This work bench type console consists of powered positioner that will turn 360° to position EMD type pressure or scavaging oil pumps for easy assembly or disassembly.

Two hydraulic presses on the bench top accomplish the removal and installation of the bushings in the pump housing.

With the adapters furnished and a few hand tools, complete repair can be done without leaving the bench.

This console, like the water pump console, requires 90 lbs. compressed air to operate. The hydraulic units are in the bottom of the bench behind doors that can be locked and an ample storage area is provided next to the pump compartment.

Tame Model 72 Hydraulic Wrench For Traction Motor Field Coils

This is the same type hydraulic wrench as the Model 70 used to torque main bearings and several other torquing applications.

It has adapters that allow tightening of all field coil and interpole coil bolts and can also be used to tighten end bell bolts.

Controls' are provided for necessary torque settings for proper torque of the field coil, interpole coil, and the reduced torque on the axle position field coil.

The machine is portable on a two-wheeled cart and operates with 110 volt AC power supply.

Proceco, known for the Typhoon type cleaning machines, is in the process of building a robot fed head cleaning machine with a planetary turntable to clean eight heads at a time and a typhoon type cylinder liner cleaning machine. The photos show before and after examples of the cleaning ability of these machines.

Other power assembly related tools are:

Tame Model 45
Valve Spring Tester

This tester has a feeder basket on top that automatically rotates and feeds the 48 springs to the dead weight test device below. When the supply of springs in the feeder is depleted it will rotate for 20 seconds and search for more springs and shut off if none can be found.

When springs drop into the transfer tube to the test device below they are fed to the spring length gauge. If a spring is too short to meet specifications it is rejected; if it passes it is fed to the dead weight tester to be qualified for tension.

Springs that qualify drop into a container that is removable to the work area. Rejects drop into another removable container that can be moved to a scrap container.

48 springs can be tested in 15 minutes without attention from an operator.

Automatic counters indicate total number tested, total short springs rejected, and total tension rejects.

The machine comes set at 186 lbs. for test, and additional weights are furnished to allow up to 200 lbs. for test.

It is powered by 80-100 lbs. compressed air and 110 volts AC.

Tame Model 80
Rocker Arm Work Bench

This bench is equipped to clamp the rocker arm and test for follower wear with a dial indicator.

If worn, the rocker arm is clamped in a follower pin clamp and press where the old pin and roller can be pressed out and new pin and roller applied.

A third fixture is provided to press the worn bushing out of the rocker arm and apply a new one at the same time.

The hydraulic unit is in the lower part of the bench and an ample storage area is provided adjacent to the pump area, both having doors with locks.

Photos 2, 3 & 4

80-100 lbs. compressed air is required to operate this console.

Tame Model 82 Head Seat Ring Qualifying Fixture

This measuring fixture employs three dial indicators and a carrier plate, indexed for an EMD head seat ring, that lifts to a preset stop allowing indicators to detect wear in three locations on the seat ring. The lift carrier is powered by an air cylinder which is supplied from the shop compressed air line.

Photo 5

Tame Model 35
Rod Torque Console

This unit clamps the wrist pin, and with the EMD rod in a vertical position drives two ratchet wrenches with hydraulic torquing cylinders controlled by a hydraulic regulator to equally torque the two wrist pin bolts to specific torque.

This machine is powered by 110 volts AC.

Photos 6 & 7

Proceco Wrist Pin
Torquing Machine

Carrier and wrist pins are held in place by a pneumatic clamp on the pin. Compressed air operates the rachets and regulates torque with air pressure regulators.

Tame Model 36 and 37
Cylinder Head Tester

Model 36 for EMD 567-B heads and Model 37 for C, D, E, and F type heads operate with a hydraulic clamp that holds the head down to a cylinder liner mock-up and a hydraulic ram to seal the water discharge outlet. A water booster power unit and a water air test circuit with water flow indicators enable the user to test a head, at the pressure desired, for leaks.

Photo 8

Proceco Cylinder Head Tester

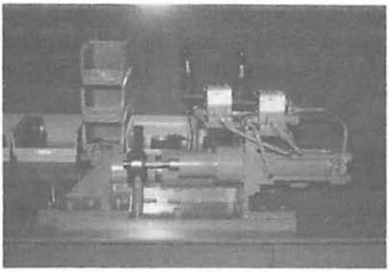
This tester uses compressed air in the head cavity and submerges the cylinder head in water with the ports sealed by a pneumatic clamping fixture.

It is lowered into the tank with a monorail hoist and can be pivoted 90° to observe air bubbles indicating leaks.

Tame Model 39 Water Test Console For EMD C-D-E-F Liners

This test console is built to adapt to a conveyor line operation and has a hydraulic head clamp to seal the head to liner water ports using a conventional seal, a hydraulic water inlet ram to seal and supply water at the cylinder liner inlet port, and necessary valves to supply air and/or water to the liner, and two water flow indicators to tell when the liner is filling and when it is completely filled for test.

Photo 2



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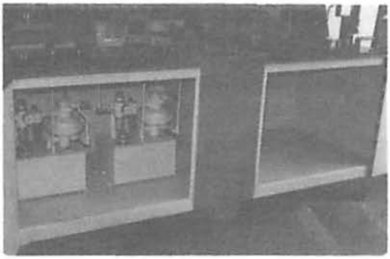

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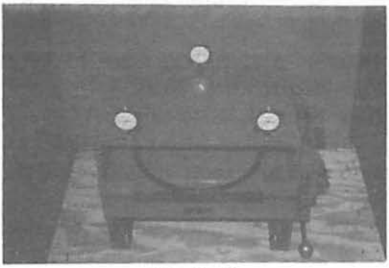

Photo 5

Photo 6

Photo 7

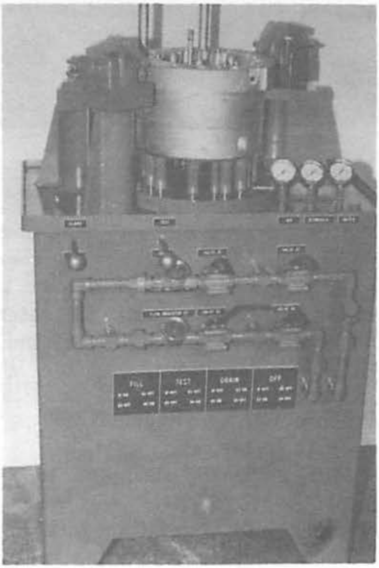

Photo 8

Air pressure to operate is 60-100 psi. Water pressure of 80 lbs. is sufficient for the test control valves, and test positions are clearly marked on the valves.

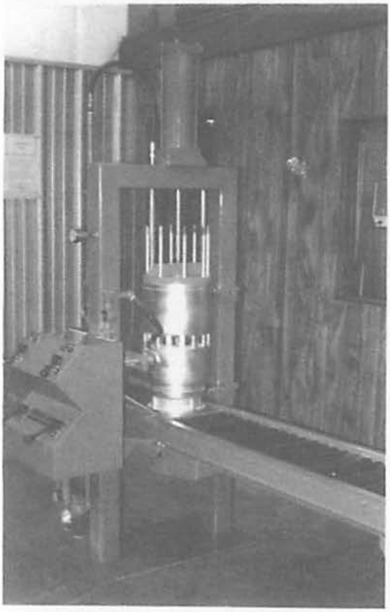

Photo 9

Proceco Cylinder Liner Tester

This tester clamps the liner ports, fills the cavity with compressed air and tilts the liner to submerge it in a tank of water, where it is observed for leak-indicating air bubbles.

Proceco EMD Cylinder Head Assembly Device

This device is designed to fit into a conveyor line. The head is clamped into a rotating fork and lifted. Valves are inserted in the head in place, springs are compressed pneumatically by a pressure plate and retainers are inserted. The assembled head is deposited fire face down on the conveyor.

Proceco EMD Piston Re-grooving Lathe

The EMD piston is placed on an arbor and held by a pneumatic cylinder with an idling pressure plate. The piston is turned by a pin that engages the internal fins and a carbide tool held in a precision cross slide cuts the piston ring groove.

Proceco Piston Phosphating Machine

This is a fully automatic four stage system which picks up two pistons at a time from an incoming conveyor and processes them and deposits the zinc phosphate coated piston on the outerlying conveyor.

Proceco Engine Rotating Device

This positioner can be used for easier disassembly and assembly of EMD engines.

The engine can be rotated into any position for the convenience of the mechanic, and the positioner can also be used to hold the engine block while it is being washed in the Proceco engine block and truck washer.

Traction Motor Gear Case Fixtures For Modification For New Style EMD Seals

Jigs for layout and cutout for new seal are shop built from EMD drawings.

Due to the light gauge of steel used for gear cases, they distort when cutting or welding.

MAINTENANCE EQUIPMENT FOR LOCOMOTIVES

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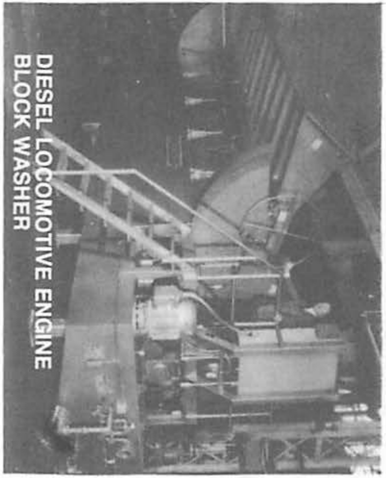


The hold-down jigs are shop built to minimize distortion and can be turned 180° to position gear cases so that welding in the new seal ring can be done in the down weld position on either side.

Radar Tester

A Radar Speed Simulator/Calibrator has been developed by Edwin Bohr Electronics for use on EMD Super Series locomotives and other radar indicator recorders.

The tester is operated from the locomotive cab. A transponder that attaches to the radar face under the locomotive is attached to the tester in the cab to produce a speed signal of 10, 20, 40, 60, and 80 MPH. A control switch allows setting of overspeed.

The tester is portable and operates from 3 flashlight type "D" cells. It is housed in a leather case.

Module or Card Washer

One railroad has found that a Kitchen Aid automatic dishwasher works quite well to clean modules or cards using the normal cycle. It is important that a low phosphate detergent which does not leave residue be used. Cascade works well with this railroad's water hardness conditions. After completion of the dishwasher cycle the cards are transferred to an oven set at 150°F to thoroughly dry all components.

REACT Alignment System

Manufacturing or Maintenance Systems of Lombard, Illinois, has a sophisticated system for accurate alignment of rotating equipment joined by shafts and couplings.

The system employs hardware to support the two dial indicators, the dial indicators, and a computer that does all the necessary calculations.

The computer actually tells the person by voice what steps to take to supply the computer with necessary information for alignment.

The computer then prints a tape on paper giving all the necessary horizontal movements and shim locations and thickness required for proper alignment.

M. M. S. plans to adapt this system to main generator and engine alignment for railroad use.

At present it can be used for smaller alignment jobs such as auxiliary generators or air compressors.

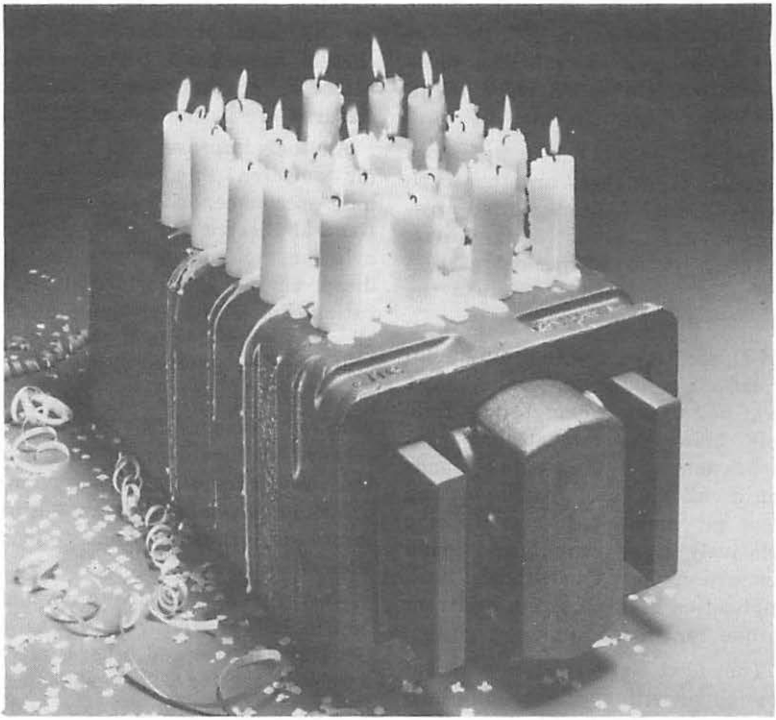
New Power Torque Wrench Developments

Hydraulic torque wrenches made by the NSW Corporation of Austin, Texas, have been used successfully in several applications on GE locomotives where high torque is required and space is very restricted.

These applications include tightening traction motor axle cap bolts, gear case attachment bolts, motor field pole bolts, fuel tank bolts and the power plant mounting bolts.

Development work on these applications was done jointly by General Electric and G&S Sales of Painesville, Ohio, one of NSW's distributors.

In each application, a regulated hydraulic control console is the



source of pressure. Operating from either 110 or 220 volts AC, the console accurately controls the pressure through a relief valve to an accuracy of one percent.

Hydraulic cylinder actuators mounted to ratchets or other type devices transfer the regulated pressure to exert a controlled torque. In many cases a special reaction fixture is also needed to take the reaction torque.

For the three traction motor applications — axle cap bolts, gear case bolts, and commutating field pole bolts — a ratchet only 7¼ inches long weighing eight pounds can do all the jobs. When working in a pit under a locomotive, the relatively light weight and small size are obviously beneficial. Each application does require a different torque reaction fixture.

The next larger size actuator (cylinder) with special tooling having a very slim profile is used to tighten fuel tank bolts — both inside and outside locations, without requiring the locomotive air reservoirs to be dropped.

This same size actuator with a ratchet can be used to tighten the long power plant mounting bolts on either side of the alternator on a GE locomotive. That is the bolt which should be stretched 0.055 inch and requires approximately 2300 pound feet of torque to achieve such stretch.

These tools are now available through General Electric. They will be listed in the next edition of GE's Locomotive Maintenance Tool Catalog. If desired, the whole kit for all applications can be purchased on a cart. The various ratchets, adapters, and reaction fixtures are in the locker.

Another improvement is in the air-powered Pneutorque wrench, long recommended and sold by General Electric for tightening the cylinder hold-down bolts on its diesel engine as a principal application. Some railroads have adopted the same wrench to torque crab nuts on EMD engines.

Older versions of this air-powered wrench had four long screws holding the upper portion of the wrench together. These screws occasionally became loose, resulting in erratic torques and noisy operation.

Now, the E. J. Daiber Company, distributor of these wrenches to General Electric and others, offers a rebuild service. They will clean, inspect and rebuild the air motor in the wrench to the new style eliminating the four long screws. This provides consistently quieter operation and even torque.

This service can be done for one-quarter to one-third the cost of a new wrench. If gear parts are needed, an extra charge is incurred.

Numerical Control Equipment And Robots

While numerical control machinery robots are still not in wide use in railroad shops, some advances have occurred recently. One function now being performed by automated equipment is the fabrication of traction motor gear cases.

The parts for these cases are cut on a Linde C M 350 plasma arc machine. This machine is a completely programmable shape cutter. Since the machine is easily programmed, many parts other than those needed for gear cases can be produced. These include pipe flanges, coupler shims, and journal box wear plates.

In order to reduce the fumes, noise and glare usually associated with high-speed cutting, all of the cutting is done under water. This underwater cutting feature also aids in controlling distortion in the finished parts.

Following the cutting operation, the top and bottom portions are formed on a Verson press while the sides are completed on a Watson-Stillman press. Both of these machines make use of interchangeable dies which allow them to be used for forming other parts not associated with gear case fabrication.

When all of the parts have been cut and formed, they are placed on specially-designed fixtures for tack welding. These fixtures are equipped with pneumatic clamps which hold the parts in place during the tack welding process.

A hydraulic servo arm is then used to move the assembled pieces to a positioner. This positioner is part of a Cyro 750 robot system which performs the final welding. The system uses a computer to coordinate the movements of an M. I. G. welding machine and the rotation of the positioner.

When the robot is activated, the welding gun and the positioner both move to produce a continuous welded seam. The robot requires approximately ten minutes to weld the outside of a case. The case is now moved to the second positioner where the robot welds the inside of the case. This cycle also requires approximately ten minutes.

Control pendants and a CRT terminal provide for the development of many different programs. This allows the robot to be used for several welding production jobs. When the welding operations have been completed, the mounting pads and parting lines are machined on a Giddings and Lewis numerical control milling machine.

Following the machining operations, the gear cases are cleaned, inspected and painted before being applied to traction motors.

This robot system for fabricating gear cases and other items is only one example of the possible uses of robots in the railroad industry.

Photos 10, 11 & 12

C. DYNAMIC ONLINE PERFORMANCE OF LOCOMOTIVES WITHOUT ONBOARD TELEMETERING

The following equipment is still under development, but the Tool Committee felt the concept is interesting enough to report on at this time.

Since the advent of the general purpose type locomotive and changes in engine crew responsibilities, information regarding op-

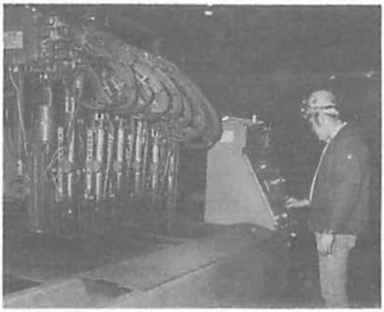


Photo 10

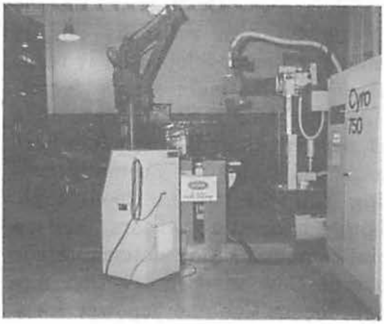


Photo 11

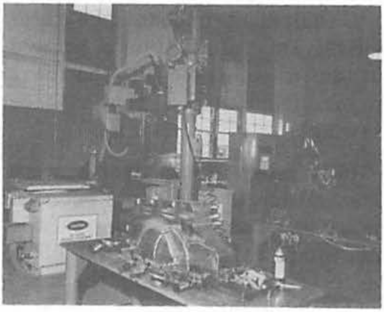


Photo 12

erational integrity of trailing units in a power consist has been unreliable. The ideal locomotive analyzer would be a personal rider for each locomotive who would monitor all phases of locomotive performance and contact maintenance terminals on equipment defects. This is not practical and thus locomotive performance is evaluated by the engineer who looks back to see exhaust smoke or by monitoring of fuel consumed during a trip.

Thus there is a need for a means of evaluating locomotive performance en route, so advance plans can be made concerning the unit's disposition upon arrival. It is desirable to develop a device which will perform this function automatically, without the use of manpower.

During normal operation, a diesel electric locomotive produces many complex energy transformations: electrical power, exhaust energy, thermal conversion from combustion, vibrations, and various magnetic fields. These energy forms were analyzed to determine if any could be monitored externally and provide relative information regarding the vehicle's performance. The intent was to monitor vehicle performance without using onboard instrumentation and telemetry.

After careful review of the locomotive systems, it was determined that the magnetic fields generated might provide the necessary information. Magtronics, Inc., of Milford, Utah, with Chief Research Engineer C. L. Lowe, sought to explore this method. Magnetic sensors were set up at a track location and magnetic signals amplified to see what information could be obtained.

The information was overwhelming. Magnetic fields were measured from the main generator or alternator, traction motors, auxiliary generator, cooling fans, and the residual magnetic fields of freight car wheel/axle sets.

The frequency output from the a-c equipment was quickly converted to engine speed. The distance and time between traction motors passing over the pickup was transformed into train speed. The calculation of engine speed and traction motor field strength, coupled with train speed, produced a ballpark figure of horsepower.

Shortly after installation, reports were received of several locomotive problems that were detected by the experimental device. Among the reports, the following problems were verified:

1) No horsepower output.
2) Low horsepower output.
3) A comparison of all the traction motor fields revealed a motor with the wrong gear ratio in the locomotive.
4) A bad power contactor was found which affected the current to a traction motor.
5) A defective wheelslip system was found due to an unbalanced condition between traction motors which was not being corrected.
6) New factory locomotives were found to have been wired wrong with the traction motor field and armatures both reversed. This did not hurt locomotive performance, but would have been bad news when making modifications or repairs from blueprints.

The most common defect picked up to date is low horsepower due to restricted fuel filters.

These tests led to the development of the Lowe Analyzer under U. S. Patent 4,179,744. A pilot model is presently in place on one of our Western railroads and is being further developed as it feeds information to maintenance forces.

At this test facility, there is a 1.4 percent ascending grade where eastbound trains are normally running full throttle at 20-40 mph. Using magnetic sensors and a mini-computer, they determine the current flow in each traction motor; locomotive horsepower; engine RPM; type and direction of the locomotive; speed of the train; and the time/date. All this is done remotely, without any telemetry equipment onboard the locomotive. This information is printed out on a computer at the next major maintenance center (see drawing).

The system uses two sensors placed about 25 feet apart between the rails. The first triggers the mini-computer; the second gives the speed of the train and the magnetic field around the traction motor. A third sensor is set at the

side of the track near the center line of the alternator, to determine engine RPM.

The magnetic sensors are high impedance coils wound on an iron core. The signals from the magnetic field around the traction motors are run through an analog to digital convertor. This signal is then logged into the computer memory as to amplitude and time. The computer processes this information and determines train speed, horsepower, type of locomotive and direction of travel for each unit. The a-c field around the alternator is picked up by another sensor at the side that is also run through an A/D convertor into the computer memory. This signal is processed to read out the engine RPM.

The main device that makes the system possible is the mini-computer used to process the data. Today's $1500 mini-computer exceeds the performance of the 1960 computer costing several million dollars. An important feature of the system is the micro computer's ability to change the magnetic signals from the locomotive into a simple English report, understandable by anyone.

As mentioned earlier, the system is still in the development stages and several changes are being pursued. The system presently cannot determine locomotive road numbers. However, additional testing of locomotive identification devices is now in process, and it is hoped to be able to provide locomotive road numbers to the computer prior to a scan. The computer will then call up a table and will select a program designed for a particular model and gear ratio locomotive. The computer can then compare its readings to a known standard and evaluate the performance accordingly.

At this time, the system does not read absolute horsepower but does provide relative data which are sufficient to indicate locomotives in trouble. The present arrangement of the pick-up sensor does not account for variances in wheel sizes, and thus, traction motor horsepower may vary. Development is continuing for means of obtaining a better figure of absolute horsepower. In addition, changes are being considered which will enable the program to identify dead units that are preceded and followed by loading units.

SAMPLE PRINT-OUT

11-1-82
11:06:47
Direction=East
Speed=30.8 MPH

Unit	Traction Motor Amps First Truck			Traction Motor Amps Second Truck			Horse-power	RPM	Remarks
3601		—			—		—	—	Unit down
2751	459	527	481	667	584	501	2778	1076	GE-C For Th. Position 8
2441	594	567	707	605	587	751	3232	1056	GE-C Rev Th. Position 8

In summary, this telemetering system can function to identify dead units, low horsepower, and units blocked down in engine RPM. With further development, the analyzer will have the capability of detecting a multitude of other malfunctions such as wrong gear ratio, electric cooling fan operation, improper alternator phase output, auxiliary generator output, car count, and length of train.

D. MANAGEMENT IN ACTION

In its constant quest for improvement, the railroad industry has invested a great deal of money in the physical plant. Much has been spent on fully equipping and training shop personnel so that maximum productivity can be attained. The final step in this process is to maximize the managerial capabilities of supervisors. Management then becomes the ultimate tool that will determine a shop's productivity level.

An effective management program will combine an acceptable style with a workable system. A manager's style and attitude is reflected in the way an employee is approached. The manager must have a system that will allow him to put his management ideals into action. Missouri Pacific's "Management in Action" program is one such system.

This system is based on the condition that motivated workers will seek satisfaction of personal goals on the job and under the right conditions the achievement of these goals will result in the attainment of corporate objectives.

What motivates workers? Dr. Abraham H. Maslow developed his "Hierarchy of Needs" describing the needs, wants, and desires that provide motivation. These needs are as follows:

— **Physiological** — need for shelter, food, water and physical activity.

— **Security** — need for protection and safety; freedom from physical and mental harm; desire for the familiar.

— **Social** — sense of belonging; to be approved of by others; to be accepted.

— **Esteem** — need of self-respect and the respect of others.

— **Self-Actualization**—to be able to realize one's fullest potential; to became what one is capable of becoming.

Seeking to satisfy these needs provides motivation:

Physiological needs can be satisfied on the job as the wage provides the means to obtain nourishing food and drink, the shelter and warmth of comfortable living quarters, as well as the expenditure of physical energy on the job. One of the basic assumptions of modern psychology is that expenditure of physical and mental energy in work is as natural as play or rest.

Security needs are satisfied at work through job security, health and medical insurance and the familiar sure feeling of accomplished tasks and repetitive duties.

Social needs are met on the job by association with others who accept one another for what and who they are, acceptance by those in authority, invitation to social occasions and a feeling of belonging.

Fulfillment of self-esteem needs can be met through achievement, promotions based on performance, ability to work with a high degree of self-direction, and the level of responsibility of the position. Respect and admiration of others is gained by reputation, recognition and oftimes longevity.

While all needs vary in degrees of intensity, importance, and energy expended in the quest of satisfying them, the need for self-actualization is even more individualistic. Self-actualization is the never-ending process of becoming what one is capable of becoming. As you live, breathe and gain in experience and exposure, your capability to self-actualize grows. The pursuit of self-actualization or personal self-fulfillment offers some explation of why the "very rich" continue to work even on unpaid volunteer projects and why others are satisfied to retire on the same job on which they began. Self-actualization can be satisfied by doing satisfying work; being allowed to set your own goals; knowing your level of effectiveness; and feeling free to be open with your superiors.

In the work environment where people live closely day to day the importance of understanding and practicing human relations is essential. Good human relations develop when the manager and employees work together in an atmosphere of mutual understanding and teamwork. An effective manager practices human relations with his employees to direct and control their working together to achieve company goals and satisfy their personal needs. The intelligent manager will involve his people, allow them to participate to gain their commitment to projects, goals, and solutions. He will realize that his employees need to:

— be treated as unique human beings, not numbers or machines.

— be noticed and recognized for their accomplishments.

— seek rewards and security.

— work in an atmosphere of trust and fairness.

— know that what they do is essential to the total effort.

The participation of the employee is sought and encouraged because the manager truly believes that all his employees will be willing to work toward attainment of corporate goals if they can at the same time achieve some of their personal goals. Through his belief in his people, the manager shows respect for the employees and a trust that they can add talents, ideas, creativity and innovation when given an opportunity to do so.

To provide a workable system we must merge an employee's personal needs with specific corporate goals. Management by objectives is a system that integrates the company's goals of profit and growth with the manager's and employee's needs to contribute and develop personally. The important ingredient to a successful program is that the individual set his own goal.

When the goal seeker is actively involved in the goal setting process, there develops a personal commitment to the goal. This commitment lends enthusiasm to attainment and also provides for satisfaction of the goal seeker's personal needs for achievement, recognition and responsibility.

Douglas McGregor's Theory Y holds that "People are much more likely to take an interest in an organization's objectives and accept the responsibility for accomplishing them if they have something to say about them in the first place."

At the end of the goal setting process the question must be asked "Whose goal is it?" What answer is given depends primarily on the goal seeker's participation in the process. He must be able to say "It's my goal. I set it and I am committed to its attainment."

Most people approach their maximum motivation when they recognize a blending of company goals with their personal goals. They see their accomplishments actually making a contribution to the ultimate corporate objective and their contribution is rewarded with:

— recognition
— opportunity
— belonging
— security
— responsibility
— achievement.

They are shown that what they do and have done yields value for them and the company.

There is a great degree of compatability between workers' personal needs and objectives of the company for which he works. The intensity of the satisfaction of these needs within the individual determines his response to achieve them in the job environment. The enthusiastic response to the challenges in M. B. O. makes a significant contribution to the attainment of corporate objectives.

Attainment of company objectives and the satisfaction of personal needs are:

— accomplished simultaneously
— dependent, one upon the other
— generally compatible

and therefore inseparable.

Corporate success is little more than the sum total of employees satisfying their needs while at the same time making a significant contribution to corporate goal attainment.

The practice of professional management requires a liberal education in the direction and control of money, materials, time and people. These are the available resources to which the manager applies his philosophy and style of management, his positive attitude, his personal strengths and skills to reach the ever increasing profit centered objectives of the corporation.

The success of the manager depends on this ability to get results through people. The methods and techniques he adopts to get results

through and with people will determine the level of his success. His personal managerial philosophy must be people-oriented as he deals with the greatest asset of the corporation—its people.

To achieve results by working with and through people, the manager must set the example and pace. He must create a productivity climate, safe environment and positive atmosphere in which his people can work toward known, clearly defined and measurable objectives.

The effective manager treats his people as unique, thinking human beings who can and will work if given challenging, meaningful work. To encourage your employees to be innovative:

— set the example and do something in a different way or try something new.

— tell them how you have implemented something new that worked (or didn't work)

— emphasize increased results not more activity.

— involve them in your plans so they can add their ideas and thoughts.

— don't tell them what to do, but ask them what needs to be done.

— give them the time for innovative thought.

— reward innovation.

Knowing there is no one best magical way to manage, a successful manager develops his own leadership style based on positiveness, candor, objectivity, consistency, active listening, sincerity, honesty, fairness, enthusiasm and integrity. His people are encouraged to participate and are involved in decision making, problem solving, goal setting and creative activities. During this involvement, they develop a commitment and dedication that ignites the motivation to achieve.

At the base of a successful management philosophy is a sincere belief that people, informed, trained, and motivated, involved and committed can work to achieve profit centered company objectives, while at the same time mutually benefiting and satisfying their needs to achieve, grow and prosper.

E.
NEW GENERAL ELECTRIC TRAINING CENTER

For many years, General Electric has operated a training school for its railroad and other customers. Assigned instructors have been well qualified. Individual attention has been paid to each student.

Most of the training methodology has been by the lecture method supplemented by the blackboard, slides, movies, videotapes and some hardware cutaways. Little opportunity existed for hands-on work. primarily due to space limitations.

Yet, for the needs of the students involved, it was recognized that hands-on laboratory work was needed to provide better understanding and retention of the material to be learned.

Concurrently, another challenge for training was emerging: The

technology being built into locomotives and the production processes used to manufacture them was on a sharp upswing. This, too, required training of a higher order both to build the product and to maintain the manufacturing equipment.

General Electric management recognized that a solution must be found to train both customers and employees in needed skills and to a depth never before attempted. A task force of key persons skilled in both training and technology was appointed.

Two years of planning and construction followed, culminating with dedication of a new Learning and Communications Center in the fall of 1982.

Floor plan of the building includes more than 40,000 square feet with a communications theater. several classrooms, and a variety of laboratories occupying most of that space. Staff offices, a dining area and building support spaces are also included.

A visitor to the building will first come into the communications area. At the center of this area is a lobby with its collection of artifacts signifying various aspects of transportation. To the left is a 300 seat theater prepared for multimedia audio-visual presentations as well as speakers. On the lectern are light controls for the entire room.

On the right of the lobby is the visitor's wing where both formal and informal discussions can take place, either in a large group or in a small private room holding only three or four persons. A small library is also included.

Going straight ahead from the lobby, one comes to the classroom and dining area. Here, four large classrooms can each accomodate 25 to 30 students without crowding. Every room has its own fully equipped projection booth for slides and movies. Videotape equipment is brought in as needed. Two of these classrooms have flat floors, while the other two have the floor in tiers.

Both compressed air and 75 volt d-c power are available in these rooms for demonstrating transportation equipment.

Across the dining area, three small classrooms can accomodate up to ten students each. As in most rooms in the building the walls are prepared so that cards, wall charts or blueprints can be pinned up without doing any damage.

A variety of computer terminals are located in the high technology classroom. Training on General Electric's new Computer Aided Troubleshooting, known as CATS, also takes place here. The Learning Center staff has its offices adjacent to this classroom.

At mealtime, mixing between various classes and between railroad students and GE employees is encouraged. This often results in an impromptu one-on-one learning situation where both parties benefit.

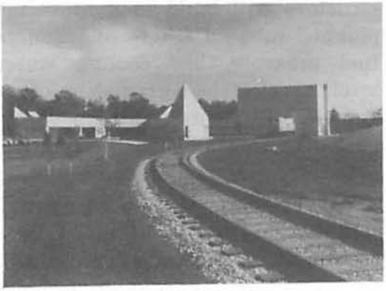


Photo 13

Photo 14

Photo 15

Photo 16

On the other side of the passageway is the high technology laboratory. An up-to-date locomotive control compartment, engine control panel, and throttle stand are installed here. That equipment is currently being interconnected and will be energized from a computerized power supply to simulate a locomotive power plant, traction motors and other components. When it is completed, students will be able to get hands-on experience in qualifying, trouble-shooting and debugging locomotive control systems. An instructor's panel will be able to insert faults.

The same laboratory also houses numerical control equipment identical to that used with many machine tools in the factory. A three-axis mill will be installed and connected to it. Factory maintenance technicians can then be better trained to maintain and repair such installations.

Located at the rear of the building, the high-bay area houses laboratories for diesel engines, rotating electrical equipment, and a complete locomotive. Students will get direct hands-on experience in engine teardown and assembly. They can take components, such as a cylinder assembly or a turbo into adjacent spaces for further disassembly if desired. The governor laboratory has a fully equipped governor test stand and will eventually have a fuel pump test stand as well. That room is slightly pressurized to exclude dirt.

Similarly, across the aisle motors and generators can be torn down and reassembled. Both the engine lab and the rotating equipment lab have individual jib cranes available.

All typical running maintenance qualification, troubleshooting, and repair tasks can be performed on a full-sized unit in the locomotive laboratory. Between the rails is a well illuminated and drained pit. A 35 ton overhead bridge crane spans the whole high-bay area, permitting complete power plant changeout, if desired. Underground storage tanks are provided for lube oil and treated cooling water. The air compressor and reservoir installation is adjacent to the pump control panel.

Due to excellent sound isolation within the building, a locomotive can be run at full power in the lab, yet it can't be heard in the classroom or communication area. Advance preparation by the instructors will build in synthesized plugged lube oil filters, inadequate fuel pressure, low cooling water level, an electrical ground or other troubles. Students will then be expected to find and fix them, using procedures learned in the training.

The upswing of technology will continue—it has never stood still. Micro-processors, for example, will be introduced as regular locomotive equipment. Factory employees will have to cope with more demanding aspects of computer technology.

General Electric is very proud of the new Learning and Communications Center. It takes pride in not only the facilities and programs, but moreso in what can be accomplished by virtue of having it. Optimism prevails concerning the tremendous training capabilities the Center holds for serving both railroad customers and General Electric's own employees.

F.

WELDING QUALIFICATIONS

One of the most important processes of modern industry is welding. It entails the joining of metals together for fabricating and repairing locomotives, cars, machines, tools and structures.

There are 34 different welding processes falling under six general categories, namely; arc welding, gas welding, resistance welding, friction welding, laser welding and brazing.

These processes of joining metal have advanced very rapidly in the recent years due to economics and reliability.

To become a welder today not only requires physical abilities, but many technical skills as well, for the complexities of knowing what weldable metal can be joined to another with the proper filler metal to resist specific loads.

Since safety is involved in the design, fabrication and repair of locomotives, cars, machines, pressure vessels, buildings and pipelines, and to minimize the danger of failure, documents are established to regulate the design, and construction of this equipment and structures. Even when safety is not involved, some products are built to meet definite requirements that insure a level of quality, uniformity or interchangeability. These documents are called specifications, standards, rules and codes.

Specifications and codes are written by industrial groups, trade or professional organizations, and each specification or code deals with applications pertaining specificallly to the interest of the authoring body. Manufacturing organizations may prepare their own specifications to meet their specific needs. The major national organizations that write codes that involve welding are listed below with their common code applications:

American Welding Society: The advancement of the science of welding is a principal aim of the AWS This organization writes codes for welding buildings and bridges; prepares specifications for welding electrodes, rods and fluxes; and sets standards for the qualification of welding operators and for the testing and inspection of welds.

American Society of Mechanical Engineers: The Boiler and Pressure Vessel Committee of the ASME establishes standards and rules of safety for the design, construction and inspection of boilers and other pressure vessels. The Committee also interprets the rules and considers requests for revisions. Fabricators or manufacturers wishing to produce vessels in accordance with the codes must obtain from the Committee a Certificate of Authorization to use the ASME nameplate.

American Society for Testing Materials: This national technical society has numerous committees, each of which issues regulations and standards in a prescribed field of materials application. Many of these pertain to construction materials and the methods of testing.

American Petroleum Institute: Preferred practices governing the design and fabrication of welded equipment and structures used in the petroleum industry are issued by the API.

American Intitute of Steel Construction: This trade organization issues specifications for design, fabrication and erection of structural steel for buildings.

Association of American Railroads: The AAR Mechanical Division also outlines welding practices that must be followed by the railroads. Section CII of its Manual of Standards and Recommended Practices covers welding requirements to be followed for freight car construction.

The railroad welder, who basically handles repairs to locomotives and cars, has for many years used the "stick" weld or SMAW (Shielded Metal Arc Welding) to handle repairs. However, in recent years the "wire feed" type of welder or GMAW (Gas Metal Arc Welding) has come into being and is now used extensively because of its flexibility and the ease with which it can handle various jobs, including automated welding.

In order to improve the work performed by railroad welders, who work on locomotives, freight and tank cars, and on tracks and bridges, the railroads are requiring the welders to become "qualified" before they can weld on railroad equipment.

This qualification is accomplished by the welder performing welds on a test plate using certain type welding equipment on a specified type base material with specified filler metal. The test plate is subjected to required mechanical tests. If tests are satisfactory, the welder is qualified to weld on equipment or to fabricate equipment using the type welds for which he is qualified.

The welder for instance would normally be qualified for fillet welding of test plates in four different positions which are flat horizontal, vertical and overhead. The welder will be properly instructed in the welding technique that is being used prior to his welding of the test plates. After the test plates are welded, they will then be subjected to the required qualification tests that comply with the welding format of various codes, such as the ASME, AWS and AAR.

Governed by the above codes, the individual railroad may set up its own format which would generally include a welding procedure specification form, a welding procedure qualification test record and a welder or welding operator qualifications certificate.

The welding procedures specification form establishes the properties of the weld material and provides direction for the welder in the qualification test. These properties and directions comply with the latest ruling code.

The welding procedure qualification test record qualifies the WPS (welding procedure specification). It contains the specific facts including base metal, specification, type and grade and the essential variables used plus the results of the tests performed on the test samples.

The welder or welding operator qualification certificate is for recording performance qualifications executed by the welder or welding operator on qualified WPS. This qualification certificate is simply documented proof of the welder's qualification on the specified welding procedure specification (WPS).

Some railroads have this welder certification information fed into the computer for ready reference or access if needed.

It should be pointed out that welders qualified or certified by one company must be requalified if they go to another company. Qualification is very specific and must cover the type of material being welded as well as the welding process or equipment being used. Also, if a person does not perform the welding operation for an extended period of time, he may have to be requalified to comply with the governing codes, before he may start welding again.

The AAR is continually striving for standardization and qualification of welders on the railroads which will ultimately make for better and safer repair jobs on locomotives and cars. The railroads, governed by the various national organizations that write the welding codes, are continually working to qualify the welders who perform the various repair jobs on locomotives and cars.

SHOP EQUIPMENT

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Tuesday, September 20, 1983

2:00 P.M.

REPORT OF THE COMMITTEE ON FUEL AND LUBRICANTS

Pre-Convention Presentation: Southern and Southwestern Railway Assn.

April 14, 1983 Holiday Inn "Gateway" Huntington, WV

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1983 TOPIC:
"CHANGES IN FUELS AND LUBRICANTS"

PERSONAL HISTORY
DONALD D. HUDGENS

Donald Hudgens was born February 23, 1940 in Omaha, Nebraska. He attended public schools in Omaha, graduating from high school in 1958. He attended the University of Omaha and received his BA in Chemistry in 1962.

Upon graduation he worked as an analyst for the Food and Drug Administration in Kansas City before returning to Omaha to accept a position as Junior Chemist with the Union Pacific Railroad in 1963. In 1965 he was promoted to Chemist and in 1970 to Lubrication Engineer and transferred to North Platte, Nebraska. In 1980 he was promoted to his current position as Manager of Field Laboratories.

He is married to the former Jackie Whitmore and they have one son and three daughters.

I.

Field Test Update Of Multigrade Oils

One section of last year's paper demonstrated potential fuel savings possible through the use of energy-conserving lubricating oils. Although slight improvements were noted in medium speed diesel engines with the use of friction modifiers, greater potential fuel savings were indicated with multigrade or multiviscosity lubricating oils.

Multigrade oils are formulated with viscosity index improvers to lower the internal resistance or friction at lower temperatures while maintaining sufficient viscosity at higher temperatures to adequately lubricate the engine. Thus a 20W-40 multigrade lubricant exhibits the characteristics of a SAE 20W oil at lower temperatures while providing the protection of the SAE 40 oil at elevated operating temperatures.

Fuel savings with 20W-40 lubricants in a full size two-cycle turbocharged locomotive engine fully instrumented on a load box have been accurately documented at various throttle positions. As expected, fuel savings were greatest at lower throttle positions, ranging from 4.5 percent at throttle position 1 to 0.5 percent at 8th throttle. Using these test data and published EMD railroad duty cycles, fuel savings for each duty cycle were predicted. They ranged from approximately 3 percent in switcher duty cycle to 1 percent in heavy duty cycle.

After stationary test fuel savings with 20W-40 multigrade lubricants were demonstrated in full size two-cycle locomotive engines, engine durability tests on U. S. and Canadian railroads were instituted to assure satisfactory lubrication performance. A major Canadian railroad started a field test in February 1981 on six new two-cycle turbo-charged 3000 horsepower locomotives using a SAE 20W-40 generation 3 TBN 10 lubricating oil. Four locomotives were operated as a control with the railroad's standard SAE 40 TBN 7 lubricating oil. After 14 months


At Conrail it takes a little less than an ounce of prevention to protect a whole engine.
All it takes is a capful of oil, a Baird Spectrometer and a few seconds on-line with the system-shared computer to determine whether problems may develop in vital engine components. Through oil and trend analysis, the operator knows if there is wear, which parts are involved, and the potential for damage. More importantly, he knows almost immediately, so that corrective action can be taken before the locomotive leaves the yard.
The Baird instrument gives reliable data fast. Five instruments in the system give Conrail locomotives a monthly checkup with clear and early warning of potential failure, and the prescription for remedy in plain English. Conrail is one of the ten major North American railroads using Baird oil analysis spectrometers to detect wear.
Compact, inexpensive, easy-to-use, reliable, rugged . . . the Baird Spectrometer is good preventive medicine for oil-wetted machinery headaches.
Conrail's Dan Reh runs Baird Spectrometer engine wear tests in the Selkirk, N.Y., facility, one of the system's five in-yard laboratories.
8176
BAIRD
Baird Corporation (Formerly BAIRD-ATOMIC)
Spectrochemical Products Division
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typical freight service and approximately 130,000 miles per locomotive, the first teardown inspection was made, with very satisfactory results relative to oil stability, wear, and engine deposits.

The test was extended with a second teardown inspection in March 1983, after 26 months service and approximately 235,000 miles per locomotive. Inspection data showed satisfactory lubricating oil stability and spectographic wear metal analysis, very similar ring, cylinder liner and thrust washer wear, and comparable piston, cylinder head, valve, and general engine deposits. These test results were presented before the American Society of Lubrication Engineers Railroad Council at Houston, Texas in April 1983. The test will continue through the end of the year with acquisition of lube oil and fuel consumption data.

A major western U. S. railroad started field tests in October 1982 in four older two-cycle 1750 horsepower locomotives using an SAE 20W-40 generation 4 TBN 13 multigrate oil with and without friction modifier. Oil analysis has indicated satisfactory performance. Limited tests indicated cold-starting benefits with the multigrade oil. In addition this road performed load box fuel consumption tests on the same class two-cycle engine. These tests in general confirmed previous documented fuel savings data obtained when using multigrade 20W-40 oil vs. SAE 40 oil.

Another major western U.S. railroad undertook the testing of 20W-40 generation 4 TBN 13 multigrade lube oil in two 4-cycle 3000 horsepower engines to determine if this 4-cycle engine would experience excessive wear with the multigrade lubricant. Each engine had four premeasured assemblies installed at the beginning of the test. Teardown inspection was made in March 1983 after 15 months and approximately 80,000 miles per locomotive. Results of this test were not available at the time of publication of this report.

Following successful field testing of the 20W-40 lubricant in both two-cycle and four-cycle locomotives, and verification of actual over-the-road fuel savings, the use of multigrade diesel lubricants may offer some significant savings to the railroad industry.

II.

Update Of Alternate Fuel Testing

As railroad diesel engine fuel oil approached one dollar a gallon, a search for less expensive fuels was undertaken by the AAR, research institutes, locomotive builders, the railroad industry, and marine users of medium speed diesel engines.

Numerous alternates and blends have received attention; however, this paper will be dedicated to residual and methanol blends with No. 2 distillate and the testing of these fuels.

Burning blends of residual fuel with No. 2 distillate in diesel locomotive engines is not a new idea. One western railroad experimented with 50 percent blend in a group of GP-9 locomotives about fifteen years ago. At that time, with No. 2 distillate selling for less than ten cents a gallon and the problems associated with handling the blended fuel, the project was terminated as not being economically feasible.

Another western railroad experimented as early as the mid-fifties along the same lines and came to the same conclusion.

A short time ago, we had No. 2 distillate fuels exceeding one dollar a gallon coupled with shortages and uncertain future supplies. More recently we have been experiencing a slight reduction in price brought about by an oil glut caused by a worldwide recession and reduction in demand. Despite this recent softening in price and surplus of product, we have no reason to believe these conditions will continue and it therefore behooves us to search for alternates both to reduce costs and assure supplies.

An eastern railroad initiated a static test of blended fuels in 1981, using a 10 percent residual/No. 2 blend in two locomotives, a GE B23-7 and an EMD GP-40. This test was conducted using the railroad's established duty cycle. Fuel usage was measured by weighing rather than by the use of flow meters. Temperatures, rack setting, and horsepower were closely monitored. No adverse conditions were experienced relating to filter plugging, injectors or nozzles. Advantages noted were a slight increase in horsepower, and fuel consumption was down slightly.

A decision was made sometime later to further test the blend using two U-18's and two GP-16's. This test ran smoothly only a week or two. Filters started to plug and became such a problem that the test was discontinued until the problems could be solved. The filters were coated with a waxy substance.

All tanks have been cleaned and the test has been started again; however, no results are available at this time.

This same eastern railroad is expanding its test with four more locomotives, beginning in March of 1983. This test will involve two GE B23-7s and two EMD GP-40s. These locomotives will be operating in general freight service over a distance of approximately 800 miles round trip, making a round trip every other day. The locomotives will be fueled at one location.

In order to assure that this will be the case, the locomotive's filler will be modified to accept only a service station-type nozzle.

Two 10,000 gallon tank cars have been set in such manner that they are siamese. As another precaution against separation of the blend, a recirculating pipe drawing off the bottom and circulating back to the top has been added.

For pumping the fuel a skid was built in the shop, consisting of a pump, filter and a metered hose equipped with service station-type nozzles.

The locomotives were brought to the shop, load tested, horsepower rated, racks set, stack temperatures checked, and mechanically inspected and all defects corrected. Lube oil and filters were also changed. A premeasured assembly was placed in positions 8 and 16 in the EMD GP-40 and in R6 and L6 in the GE B23-7. All locomotives are equipped with fuel heaters and fuel lines were wrapped with insulating tape.

At this writing the test is just beginning. The results will be presented in a later paper.

A western railroad initiated a test in December 1981, using a 20 percent residual/No. 2 blend in two locomotives, a GE C30-7 and an EMD SD40-2, which were in captive service in iron ore train operations. This blend approached the limits of fuel specification by engine builders, ie: cetane below 40, viscosity about 42 percent higher than typical No. 2 fuel (see table 1). This train would run loaded from Atlantic City, Wyoming to Geneva, Utah, a distance of 350 miles with servicing being performed at Salt Lake City, Utah. The test was to have run one full year but was extended to fifteen months because of a slowdown in the schedule at the steel mill and a subsequent reduction in the accumulated mileage on the engines. Even with the extended time, only about 75,000 miles were accumulated on each engine; about half the mileage normally expected for this period of time. A saving of about six cents a gallon, not counting the increased BTU content, would result assuming no adverse effect on locomotive maintenance. The primary objective of the test was to determine if the use of blended fuel would result in higher maintenance costs, nullifying any savings from the reduced cost of the fuel. At the beginning of the test, four premeasured test assemblies were applied to each engine, R3, R6, L3, L6 in the GE and 3, 6, 11, 14 in the EMD. Another GE with 4 premeasured test assemblies was the control unit and operated on 100 percent No. 2 fuel.

The locomotives in this service were not without problems. The EMD locomotive lost two turbochargers, one in May and one in December of 1982. The concensus of opinion was that both were lost because of excessive idle and dynamic brake operation, causing build-up of unburned residual fuel in the exhaust manifold which ignited, resulting in an overspeed-overheat condition. This build-up of residual fuel had been noted on several occasions and would at times even spit unburned residual fuel out the stack. On these occasions, careful self-loading would harmlessly burn the residual fuel out of the exhaust manifold. A second smaller fuel tank on board, to contain only No. 2 fuel to be automatically used in idle and dynamic brake operation was installed in January 1983, in the hope this would solve the turbo failure problem. During the first 12 months of the test, in addition to the turbochargers, two power assemblies were changed because of bent or broken valves and three

TABLE 1

	Typical #2 Fuel Fuel	20% Residual Blend	10% Residual Blend
API Gravity	37.0	25.8	30.4
Flash, P.M. °F	165	194	170
Vis @ 100°F SUS	34.8	53.4	39.6
S&W, Vol. %	–	<0.05	
Distillation °F IBP	390	420	383
10%	435	473	434
50%	497	552	523
90%	597	-	630
EP	601	635	630
% Recovery	99	86	93
Cetane (Charted)	48.5	36.9	40.0
Carbon Residue, Wt.%	-	3.8	1.3
Carbon Residue (Wt.% on 10% Bottoms)	0.2		
Sulfur, Wt.%	0.27	0.55	0.47
Vanadium ppm	-	42	-

injectors were changed due to sticking. Examination of the engine during regularly scheduled inspections showed satisfactory compression readings, lead readings and ring and crown inspections. Some light "carbon dragging" was noted on several liners but no serious problems were noted. The air box itself seemed to be excessively dirty at the time of each inspection and was thoroughly washed. The deposits varied in thickness up to 1/4 in. in some areas. These deposits were of a black "gritty carbonacious" nature and laboratory analysis showed its origin to be the fuel. Speculation is that excessive idling would allow unburned residual fuel to accumulate into the air box where it would "dry" into the deposits noted.

It was necessary to change two GE turbochargers for cleaning. The nozzle rings of both were coated with a heavy tar-like material which was attributed to the fuel and to idling for many hours at temperatures below 20°F. Eight power assemblies were changed. None of these, however, were the premeasured ones applied at the start of the test. Three of the eight removed were changed because of water leaks and not because of the fuel. The other five were changed due to low compression found on inspection. One of these five was badly scored due to fuel washing the lubricant from the liner as a result of carbon buildup around the exhaust valves which prevented the cylinder from firing. No mechanical defects were found in the other assemblies removed. A number of air intake ports looked as if they had been painted with a very high gloss black paint. Laboratory analysis of this black deposit showed it to be dried residual fuel. Although it looked wet, it was for the most part dry and leathery to touch. A normal air intake port on a GE engine would have a buildup of flat black fluffy appearing dry carbon which in time would constrict the port opening enough to affect engine operation. Curiously, the ports which had the glossy residue seemed to have much less constriction of the total area.

In July of 1982, another test was started on this same railroad using a 90/10 blend of residual fuel. This test involved a GE C30-7 and an EMD SD40-2 operating in local service out of Green River, Wyoming. In November, 1982, this test using 10 percent residual (Table 1) was expanded to include ten older EMD units (1 GP-9 and 9 GP-30's) used in local service in the Ogden, Utah area. At the time of this writing, one turbocharger has been lost in a GP-30 and its loss was attributed to the fuel.

The use of residual/No. 2 blends in this railroad operation was accomplished but some problems were encountered. It may be that 10 percent of this No. 6 blend in this service is the maximum acceptable concentration. Problems in handling the residual product and proper mixing of the blends have yet to be worked out if the use of this fuel is to be expanded to include the entire fleet.

One builder has reported on experiments with methanol as a fuel extender. This work has been previously reported; however, it bears repeating.

In this system, the methanol is emulsified with 2-D just prior to injection into the engine. Other methods of burning methanol in a diesel engine are available such as (1) burning the methanol as a mixture with another fuel or additive to achieve appropriate cetane number, or (2) separately introducing the methanol into the combustion chamber by carburation or dual in-

jection. In this method the methanol would be mixed and burned with a pilot charge of good cetane quality.

Of the various methods of burning two fuels, the emulsion method appears to be very practical for today's locomotive diesel engine. This approach utilizes a system in which the diesel engine can operate on straight diesel fuel, or an emulsion of 75 percent diesel and 25 percent methanol. See Figure 15 on Page 287.

In the diesel fuel mode, fuel is drawn from the diesel tank by a standard fuel pump and distributed as follows:

1. Part of the diesel fuel passes through a fuel supply line and check valve to the suction side of a circulating pump which feeds the engine through an open solenoid valve;
2. Fuel not consumed by the engine is circulated through a heat exchanger which is cooled by the excess fuel delivery from the standard fuel pump, and re-supplied to the engine.

In the diesel fuel-methanol mode an additional double pump is activated in throttle five and above. Diesel fuel, as well as methanol, is fed through the dual pump and two separate lines help to maintain the mixture at the 75-25 percent by volume design point by returning the excess of each fuel to its respective fuel tank prior to mixing.

Beyond the mixing tee, the diesel fuel and methanol are fed to the suction side of the circulating pump and then through a hydroshear, or emulsifier. This device provides the final emulsion just prior to injection. It should be re-emphasized that in this mode of operation the solenoid valve is closed to divert the fuel into the hydroshear. Excess fuel is again recirculated, resupplied, and re-emulsified for use by the engine.

Dual fuel operation automatically occurs in notch 5 through 8 when the locomotive selector is set for the dual fuel mode. A special governor automatically provides 16 percent more fuel in these notches to compensate for the lower heating value of the mixture and maintain equivalent horsepower.

Although testing of this system has been quite favorable, durability of engine components while operating on this type of fuel has yet to be established. Corrosion generated by formic acid products may adversely affect cylinder wear and lubricant life. Due to the relatively poor combustion properties of the blend at idle and light load, the system has been designed to operate on the blend only at 5th throttle and above. As more experience is gained using methanol as a fuel extender, these limitations may be reduced.

Other problems of major concern when using methanol are storage and handling. Approximately twice the storage volume is needed for methanol compared to diesel fuel on a BTU basis. In addition, due to the low flash point and toxicity of methanol, special safety precautions must be taken when storing or handling methanol at the locomotive fuel rack.

The locomotives operating on the diesel-methanol emulsion are equipped with special fuel tanks. The methanol tank is located in the center of and surrounded by the 2-D tank. This arrangement offers protection to the methanol tank from puncture. In addition to the special fuel tank arrangement, special fillers must be provided on the locomotives and at the storage tanks.

Even though the immediate crisis has dissipated, and the price of fuel softened, work continues with alternates and blends for the inevitable day when the oil glut becomes a memory and the economics of these fuels may become very attractive.

III.

A Review Of Locomotive Fuels

Much has been said about the decline in diesel fuel quality the past few years. With the exception of a short period in 1979, distillate fuel meeting ASTM D975 No. 2D specifications has been available in sufficient quantity to meet the consumption requirements of U.S. railroads. However, a gradual recline in diesel fuel quality is occurring within the framework of No. 2D requirements.

The reasons for the decline in quality are well known. Crude oil for refining is becoming steadily heavier, yielding smaller quantities of straight run distillates. Greater quantities of cracked gas oil are required to make up the difference. With today's high crude oil prices, refiners are converting deeper into the barrel to meet the demand for light products. Jet fuel is competing for some of the same material as diesel fuel because their boiling ranges overlap. The straight run distillates preferentially go into jet fuel with higher quality requirements. Distillates are being used as petrochemical feedstocks in greater quantities.

Properties that can be affected most by these changes are API gravity, cloud and pour points, cetane number, stability, sulfur content and distillation range. These properties will be discussed individually below.

API Gravity and Heating Value

As diesel fuels contain increasing portions of cracked gas oils, their aromatics content increases and their API gravity decreases. A straight run diesel fuel will have a typical API gravity of 38.0 while a diesel fuel containing cracked gas oil will have a typical API gravity of 32.0 to 34.0. API gravity alone does not relate directly to quality, but it does relate directly to heating value. On a volume basis, the lower the API gravity, the higher the BTU content of a fuel. A low API gravity fuel delivers more power (higher mileage) than a high API gravity fuel. Table 2 lists the relationship between API gravity and heating value.

TABLE 2 — API GRAVITY VS HEATING VALUE

API Gravity @ 60°F	Net Heating Value BTU per gal.
26	135,800
28	134,600
30	133,300
32	132,100
34	130,900
36	129,700
38	128,500
40	127,300

It can be seen that a fuel with 32.0 API gravity has 2.8 percent higher heating value than a fuel of 38.0 API gravity.

Cloud and Pour Point Changes

Low cloud and pour points are important for trouble free operation during the winter in northern latitudes. Cloud point is defined as the temperature at which wax first begins to precipitate from a fuel. Pour point is defined as the temperature at which a fuel becomes solid (loses its mobility). These two properties are related to each other and they are affected by boiling range and paraffins content of the fuel. The presence of aromatics tends to lower cloud and pour points.

Wax crystals in a fuel at its cloud point temperature or slightly below will plug fuel filters, stopping fuel flow while it is fluid enough to flow through lines. A fuel that is below its pour point temperature is solid and it will not flow through fuel lines. By locating fuel filters in the warmer areas of the locomotive, the harmful effects of cloud point can be minimized. Most major railroads are installing fuel heaters, heat wells or mixer dividers to keep the fuel above its cloud point temperature.

From an operational standpoint, the best way to lower cloud and pour points is to add No. 1D fuel. The low boiling range of No. 1D fuel tends to keep wax in solution and thereby lowers cloud and pour points. This technique has its drawbacks. No. 1D fuel is expensive and in short supply, raising the price of the resulting No. 2D fuel. Addition of No. 1D fuel raises the API gravity so the user gets less heat at a higher price.

Additives are quite effective in lowering pour point. They function by interfering with wax crystal lattice growth which forms a matrix that traps fluid fuel and renders it immobile. A fuel below its pour point may be less than half solid wax, but immobile. Pour depressants are more cost effective than No. 1D fuel in lowering pour point and they have no effect on API gravity. Unfortunately, additives will not lower cloud points. The more effective additives may alter growth in some fuels to the extent that most of the wax crystals will flow through conventional fuel filters.

Cetane Number

Cetane number is a measure of a fuel's ignition quality as measured by a standardized single cylinder engine test, ASTM D613. It relates to ignition delay, the small time interval between the beginning of fuel injection and ignition.

Higher cetane fuels have shorter ignition delays while lower cetane fuels have longer ignition delays. Since the diesel engine is dependent on auto-ignition, short ignition delay improves startability and warm-up and reduces combustion noise (diesel knock). **Figure I** shows the effect of cetane number on cold starting temperature. It is possible to lower the starting temperature of a diesel engine approximately 1°F for every increase in cetane number. The shaded area illustrates the variation in effectiveness with different fuel-engine combinations.

During the last 10 years, the average cetane number of railroad diesel fuel has declined 3.9 units, from 47.2 to 43.3 as shown in **Figure 2.** Even though 43.3 cetane number is well above the 40.0 minimum specified for ASTM D975 No. 2D fuel, some suppliers are using cetane improvers to achieve the minimum limit.

The problem of low cetane number is usually related to the amount of cracked distillates contained in the diesel fuel blend. These cracked distillates contain larger amounts of aromatic hydrocarbons which lower the cetane number. The fuel components of distillate fuels are listed below with respect to their cetane contribution.

Fuel Component	**Cetane Contribution**
Linear paraffin	Highest
Branched paraffin	↑
Linear olefin	│
Branched olefin	│
Naphthenes	↓
Aramatics	Lowest

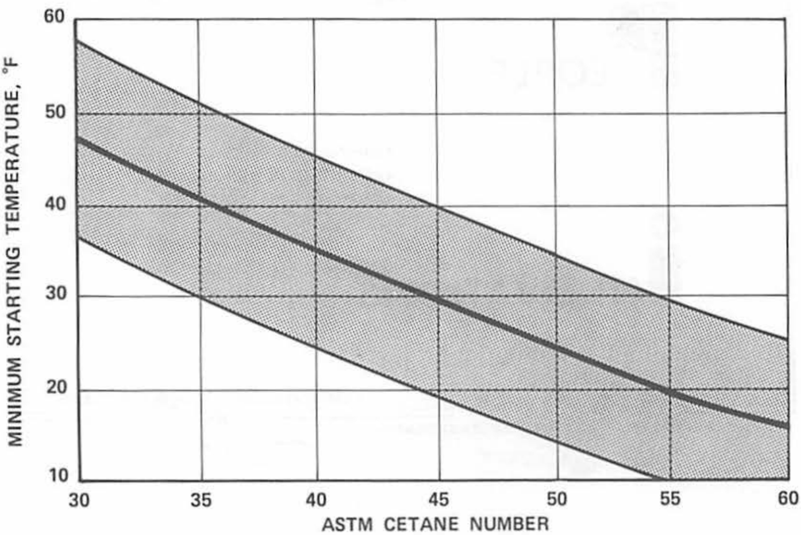


Figure 1.

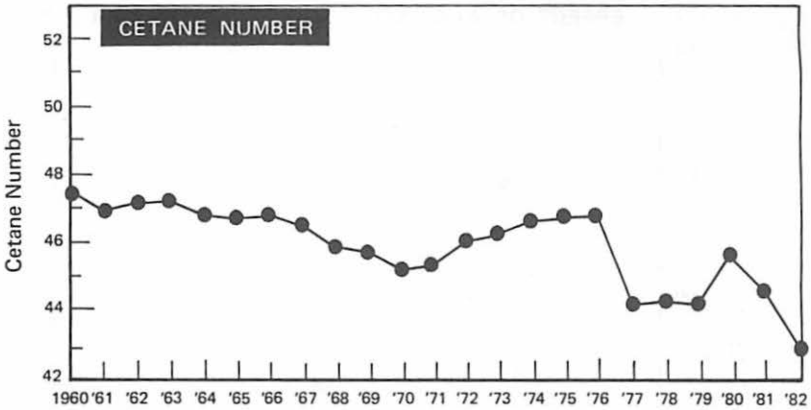


Figure 2.

Little or no benefit results from using a fuel whose cetane number is higher than that necessary to meet the performance requirements of the engine involved. **Figure 3** shows the general relationship between cetane number and aromatics content.

Cetane Number Improvers

Ignition quality of a fuel can be improved several cetane numbers by the use of cetane improvers. The degree of response to cetane improvers is dependent upon the fuel composition. **Figure 4** shows typical high and low response curves.

The high response fuel is one rich in paraffins and the low response fuel is one high in aromatics. Most fuel falls somewhere in between. Fuels with the greatest need for cetane improvement respond to additives the least.

Cetane Improver Effectiveness

In warmed up engines, cetane numbers obtained by using cetane improvers are equivalent to natural cetane numbers at all engine loads. In cold engines, the additive-produced cetane quality may be better, equal to or less than natural cetane numbers, according to one major additive supplier. Experience has shown that, in most cases, additive produced cetane numbers are less effective than natural cetane numbers in cold starting and warm up. The first increment of cetane improver raises the cetane number more than succeeding increments. In most cases cetane improvers give little additional benefit above 0.2%v.

Calculated Cetane Index

Determining cetane numbers by the engine method, ASTM D613, is both expensive and time consuming. Several correlations have been worked out to estimate cetane number quickly and accurately. These correlations combine physical and

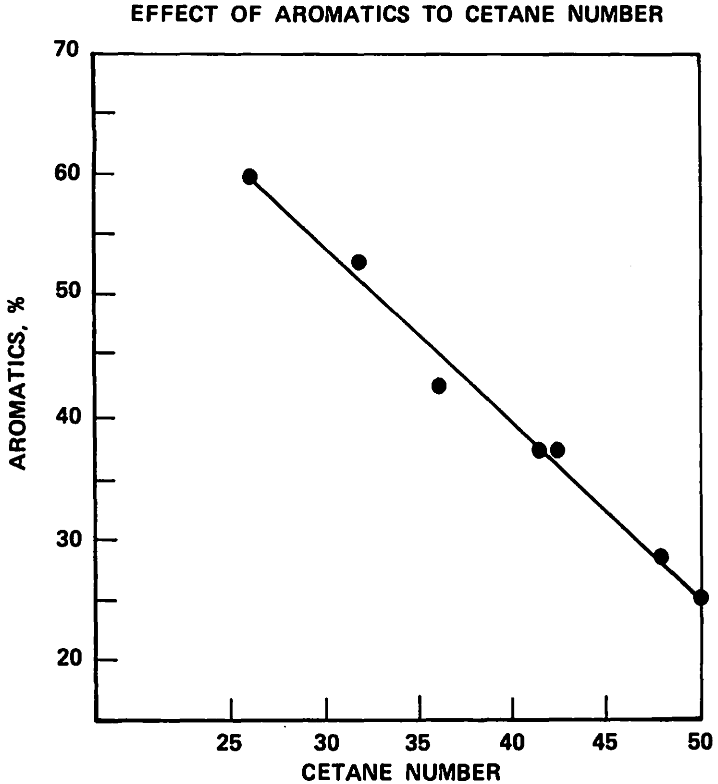


Figure 3. Effect of Aromatics to Cetane Number

chemical tests with formulas to come up with a calculated cetane number. The most commonly used method for estimating cetane number is Calculated Cetane Index, ASTM D976. This method is a formula based on the fuel's API gravity and mid-boiling point applied in the form of a nomograph.

When the Calculated Cetane Index method was first introduced several years ago, it was fairly accurate in predicting the cetane number of the largely straight run fuels of that day. However, as the aromatics content of diesel fuels has increased in recent years, the accuracy of predicting cetane number by Calculated Cetane Index has decreased. ASTM D976 was revised in 1980 to improve its accuracy. The revised formula is more accurate than the previous one around 40 cetane number, but its accuracy falls off in both directions from 40. For aromatic fuels in the low ce-

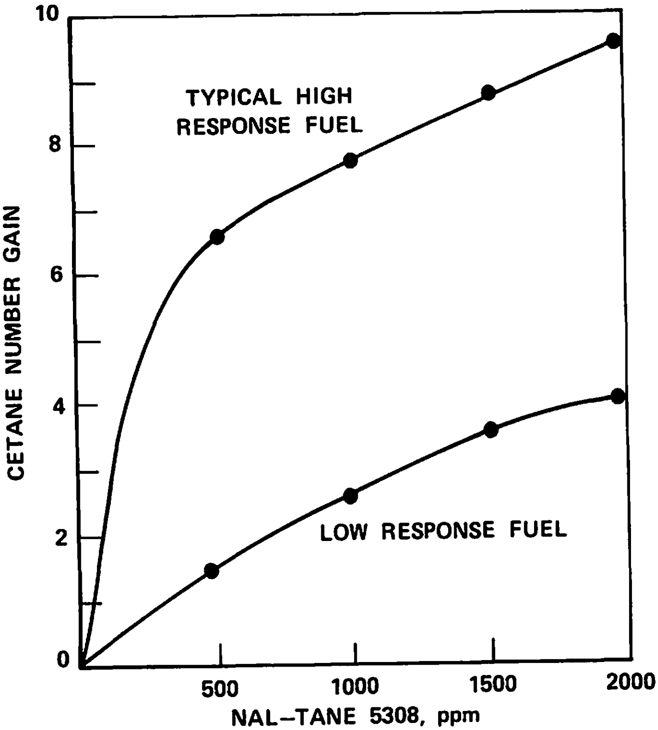


Figure 4.

tane number range, Calculated Cetane Index can yield numbers several units too high. Work is still in progress to further improve the accuracy of Calculated Cetane Index over a wider cetane number range.

Calculated Cetane Index cannot be used to predict the cetane number of fuels containing cetane improvers. The small quantity of additive present (about 0.1%v) has negligible effect on API gravity and mid boiling point while having a significantly beneficial effect on ignition quality.

Stability

Cracked distillates are potentially less stable in storage than straight run distillates. With increasing fractions of cracked gas oil in diesel fuel the propensity toward a decline in stability exists. However, treating of cracked distillates in the refinery renders them stable. Diesel fuel additives can also be used to improve storage stability. Reputable suppliers target for a diesel fuel storage stability of one year before stability related problems begin. One major western railroad reports that some decline in fuel stability has been noted since 1973 but stability has leveled off since 1980. Filter plugging due to fuel instability is not a problem on that railroad. Other railroads report that fuel instability limits filter life to less than 90 days in some cases, possibly due to onboard heating.

Fuel storage stability is assessed in accelerated aging tests where the fuel is heated to temperatures of up to 300°F for specified periods. The presence of cetane improvers interferes with accelerated aging tests because they are unstable at elevated temperatures. Extensive testing by additive suppliers and refiners has shown that cetane improvers have no adverse effect on ambient storage.

Railroad test department representatives ask about the stability of cetane improved fuels that pass through the locomotive's fuel system and return to the tank. This excess fuel is subjected to elevated temperature for a short time. Your committee has no data from a controlled test to answer the question. Since the use of cetane improvers is expected to increase, your committee will keep the question under surveillance.

Sulfur

Sulfur is present in varying amounts in all petroleum fuels. When the fuel burns, the sulfur is converted to sulfur oxides, some of which can end up as sulfuric acid. Corrosive wear rates are related to the sulfur content of the fuel. It is important to keep the engine temperature above the dew point of sulfuric acid to minimize corrosive wear rates of piston rings and cylinders. Figure 5 relates fuel sulfur content with sulfuric acid condensation temperatures at various cylinder pressures.

With low sulfur fuels, it is relatively easy to maintain combustion zone temperatures above the dew point of sulfuric acid (160°C or higher).

The corrosive effects of sulfur acids are minimized by lubricating oil alkalinity. When TBN of the oil is depleted, wear rates accelerate rapidly.

Fuel suppliers have predicted higher sulfur content for No. 2D fuel for several years. However, these predictions have not materialized. Conservation measures have reduced consumption of all types of fuels to the point where the oil refineries in the U. S. are running below 70% of capacity. Ample desulfurization capacity exists to remove sulfur from distillate fuels. It is environmentally unacceptable for sulfur content of automotive diesel fuels to increase substantially. Some states have placed a lower limit than the No. 2D specification on the sulfur content of fuels sold in their state. Figure 6 shows the average sulfur content of railroad diesel fuel since 1960. It will be noted that there has been a slight upward trend

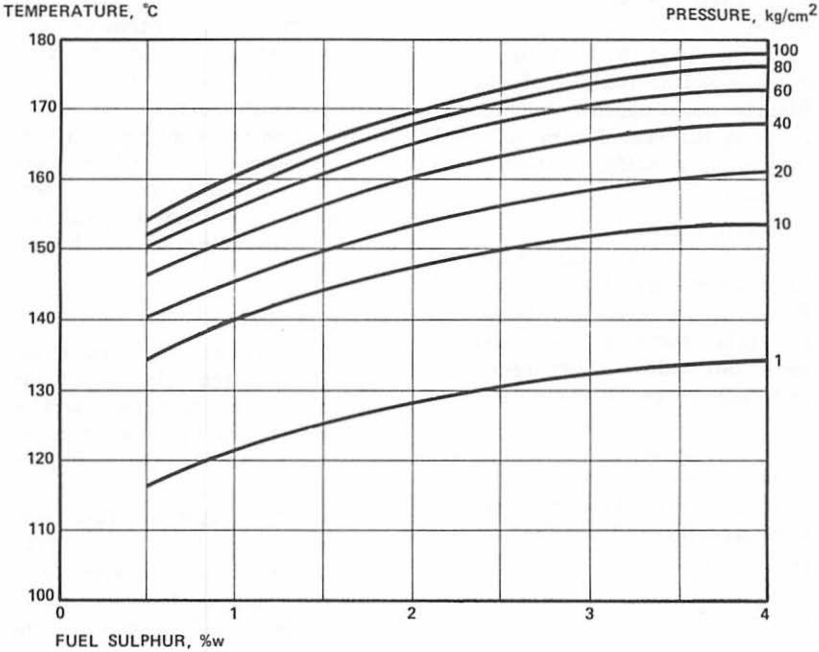


Figure 5. Condensation Temperature of Sulphuric Acid Related to Fuel Sulfur Content

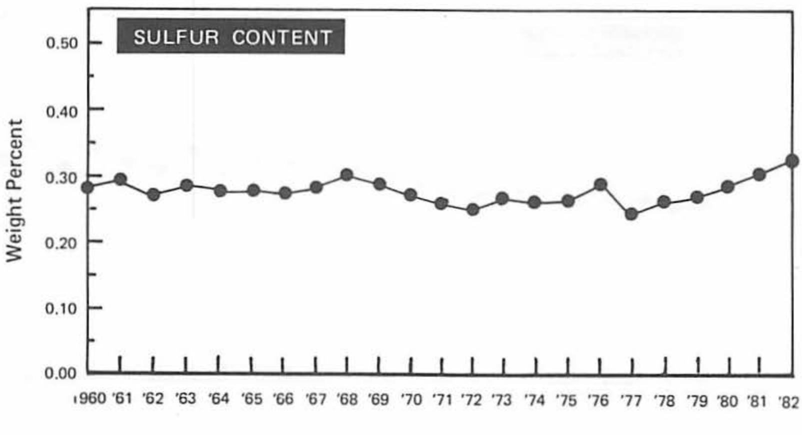


Figure 6.

since 1977, but at 0.33%w, sulfur content is well below the 0.5%w max. for D975 No. 2D fuel. The average sulfur content of No. 2D fuel is not expected to increase much in the near future, although the range of sulfur content is expected to broaden.

Distillation Range

The distillation range of No. 2D fuel has changed little since 1960. Front end volatility is important for cold starting and warm-up while tail end volatility relates to hydrocarbon and particulate emissions (smoke) as well as engine deposits. **Figure 7** shows the 90% point of railroad diesel fuel for the last 22 years. The increase has been less than 10°F. Ten percent point and end point have changed less.

Mercaptans

Mercaptans are chemically active, sulfur containing hydrocarbons occurring naturally in crude oil and also formed in certain refining processes. Untreated distillates contain mercaptans that impart a sour, objectionable odor. Mercaptans are corrosive to copper parts and they are sludge and varnish precursors. Distillates are normally treated to convert mercaptans to non-reactive disulfides or they are removed by hydrotreating.

Alternate fuels

Locomotive fuel costs have increased about ten fold during the last decade and now represent a very significant portion of total operating costs. This has prompted the railroad industry to look for alternate, less expensive fuels, but sources other than petroleum have been disappointing. Alternate fuels from tar sands, shale oil, coal, biomass. etc. will probably continue to be more expensive than petroleum derived fuels through the end of the century.

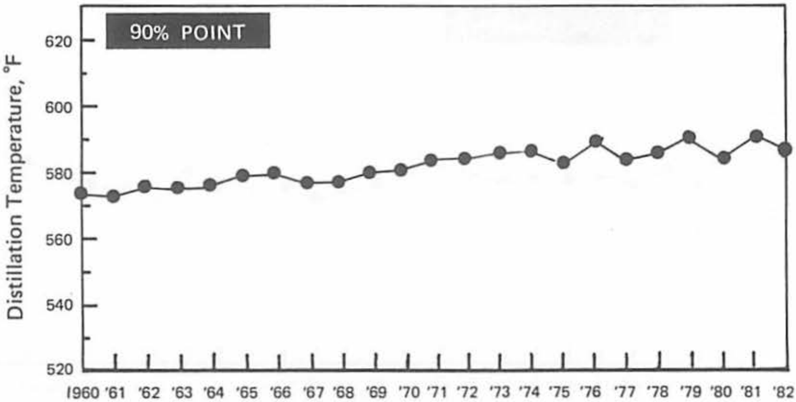


Figure 7.

The availability picture has changed markedly since the shortages of 1979. Both crude oil and No. 2 diesel fuel are in long supply. For the first time in 10 years diesel fuel prices are dropping. As a result, interest of some operators has declined. However, there still exist valid cost-saving reasons long-term for investigating alternate petroleum derived fuels.

Traditionally, No. 2 diesel fuel has sold at a price about 20% higher than crude oil while residual fuel oil has been priced at about 80% of crude oil. If crude sells for $30 per barrel, diesel fuel would be about $0.86 per gallon and residual fuel would be $0.57 per gallon. The relationship between the costs of these fuels and crude oil will probably hold regardless of how crude oil prices may fluctuate. There is little likelihood that crude oil prices will decline to the point where alternate, lower cost fuels are not attractive. It is always possible that instability in the Middle East could result in crude oil price escalation.

Two potential alternatives now exist for cutting fuel costs: i.e. (1) the use of cracked distillates of lower than No. 2D quality, and (2) the use of distillate/residual fuel blends. Both these alternatives have limitations.

Even when cetane improver is used, the amount of cracked distillate that can be present in No. 2D fuel is limited by the cetane number specification of min. 40. Some refineries have cracked distillates in excess of what can be blended into No. 2D fuel that are currently being used as marine diesel fuel, cutter stock for residual fuel or as process oils. In the future, the quantity of cracked distillates is expected to increase. This material is similar to the diesel fuel produced from tar sands in Canada and used in large volumes by the Canadian railroads. Typical properties of the tar sands fuel appear in the 1980 edition of LMOA on page 212.

The principal properties where the cracked distillates fail to meet No. 2D specifications are cetane number and sulfur content. No standard industry specification exists defining a cracked distillate fuel that would be satisfactory for use in locomotives, although locomotives can operate satisfactorily on fuels of lower quality than No. 2D. Such a fuel was described by the propsed ASTM D975 No. 3D fuel reported by your committee in 1980 (LMOA page 205). The adoption of Grade No. 3D could serve as a standard for cracked distillate fuels for use in locomotives. Availability of cracked distillates may be regional and seasonal and thereby affect continuity of supply.

Perhaps the best procedure for obtaining cracked distillates is via inquiries from the railroad representatives to their fuel suppliers. A railroad would first have to decide upon a minimum performance quality, taking into consideration the locomotive manufacturers' recommendations. One alternative would be to obtain fuel from the suppliers meeting the railroad's minimum standards. Another alternative would be to purchase fuel of lower than minimum quality for blending with higher quality fuel on site. It may be possible to obtain low quality cracked distillate that, when blended with high quality No. 2D fuel, would conform to No. 2D specifications.

The price of cracked distillate fuel would have to be negotiated on an individual basis. Although its price reduction below No. 2D fuel would probably not be great, a secondary benefit would result from its high heat content for better mileage.

Sulfur content of cracked distillates can be higher than the sulfur content of available No. 2D fuel. Most cracked distillates have sulfur contents below 1.0% weight. Corrosive wear associated with these fuels can be controlled with high alkalinity lubricants and the maintenance of proper jacket water temperatures.

Residual Fuel Blends

A greater potential for saving lies in the use of residual fuel blends. Residual fuel, such as No. 6 fuel oil, is priced at about two-thirds of the price of No. 2D fuel. The higher the percentage of residual fuel in the blend, the greater the savings. However, lower fuel cost must be balanced against higher maintenance costs.

Availability

Because of its "dirty" nature, residual fuel cannot be moved through products pipelines. Bulk supplies of residuals are located at refineries and at terminals supplied by water transportation. The cost of transporting residuals in tank cars for long distances would make their use questionable. The distribution system for residuals does not coincide well with the locations of many railroad fueling stations. Distribution logistics for residual fuel could improve as demand increases.

The locomotive manufacturers recognize the cost reduction possible by using residual fuel blends and they have issued specifications and guidelines covering the use of these fuels. A large Northwest railroad began a test of fuel containing 10% No. 6 fuel oil about two years ago. That test was quickly aborted because the blended fuel was unstable (instability will be discussed below). Other major railroads have had varying degrees of success with blends containing 10% or 20% residual fuel.

In general, the railroads have purchased blended fuel based on the percentage of residual it contained. This procedure allows for large variations in fuel quality due to the differences in residual fuels. Perhaps a better way would be to purchase blended fuel against specification limits. No performance penalty would result from higher amounts of good quality residual compared with a lower amount of poor quality residual.

Separation of Asphaltenes

When the large Northwest railroad alluded to above purchased a 90/10 blend of No. 2D fuel and residual fuel, precipitation of asphaltenes occurred. Incompatibility of residual fuel blends is a little understood phenomenon that can cause severe operating problems. An explanation follows.

A residual fuel oil can be looked upon as a dispersion of asphaltenes in an oily medium (the continuous phase) which is known as the "maltenes." The definition of the asphaltenes and the maltenes relates to the fact that, when a fuel oil is diluted with a low molecular weight paraffinic solvent (i.e. low carbon/hydrogen ratio) such as n-heptane, a brown or black precipitate is produced. The part of the fuel soluble in n-heptane is defined as the maltenes. Thus, the asphaltenes together with the maltenes comprise the fuel oil; the proportion of each will depend on the nature of the fuel oil.

Asphaltenes are complex, high molecular weight compounds of very high C/H (carbon/hydrogen) ratios, but containing, in addition, small amounts (also depending on the nature of the fuel oil) of sulfur, oxygen and nitrogen. The asphaltene is believed to exist in the fuel oil in a structure called a "micelle." This can be envisaged as an asphaltene nucleus to which is absorbed a surrounding zone of high molecular weight aromatic hydrocarbons from the maltenes, of a slightly lower C/H ratio than the asphaltene itself. In turn, this zone has a similar zone—of slightly lower C/H ratio — absorbed to its surface, and so on, until, in the outermost zone of the micelle, the C/H ratio approaches that of the continuous phase.

The asphaltene micelle structure is illustrated diagrammatically in Figure 8. It will be appreciated that, although the hypothetical zones are shown as separate entities. they do in fact merge into one another.

Paraffinic distillates have low C/H ratios and, therefore, are poor cutter stocks for blending stable residual fuels. The greater the quantity of cutter stock in the residual fuel blend the more difficult it becomes to maintain the stable asphaltene dispersion. It can be seen that a small quantity of residual fuel diluted with a high ratio of paraffinic No. 2D fuel would tend to precipitate asphaltenes.

A simple test has been developed to determine the stability of blended fuel. ASTM D 2781, "Compatibility of Fuel Oil Blends by Spot Test," uses paper chromatography to assess the compatibility of residual fuel and distillate diluents. It can also be used to measure the compatibility of two different blended fuels when mixed together. A spot rating system of one to five is used, with a rating of two or less being satisfactory.

Sulfur Content

The deleterious effects sulfur content has on engine wear life and lube oil change interval are well known. The use of high alkaline reserve lube oils can be most effective in reducing the effects of high fuel sulfur levels and associated wear if a conscientious pro-

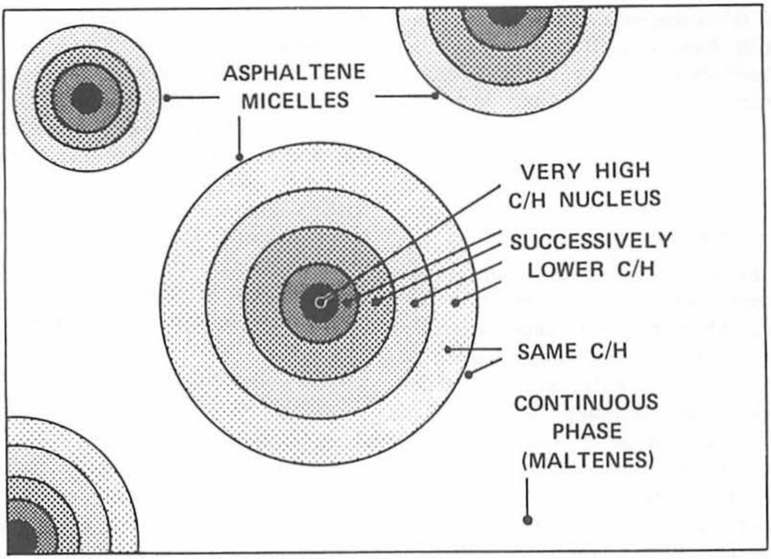


Figure 8. Hypothetical Asphaltene Micelle

gram of monitoring lube oil condition is employed to implement changes as well as assist in the assessment of engine condition. In addition, it is important to keep water jacket temperatures high enough to minimize the low temperature corrosive effects which can result when operating with combustion temperatures below the dew point of sulfuric acid solutions. (See **Figure 5**) This can be a problem in mid-winter operation.

Catalyst Fines

EMD found in engine tests that the effect of very minute and abrasive catalyst fines is among the most severe relating to obtaining reasonable performance with blended fuels. Rapid deterioration of injector components directly affects the combustion process leading to increased deposit levels and turbocharger surging. Power assembly performance is also influenced in the form of extremely rapid wear which can lead to scuffing.

The mechanism by which catalyst fines produce scuffing is explained as follows. The fine is embedded in the ring face, which is the softer of the interacting ring and liner materials. The fine resides temporarily in the ring face, as shown in **Figure 9**, until intimate contact is made between the fine and the hard chrome surface of the liner.

This contact results in the removal of the fine and the creation of microscopic scoring as the fine is dragged out. Repetitive scoring produces material removal between score marks and other localized damage. The cumulative effect of this damage eventually becomes visible as scuffing, Figure 10, which in time is transferred to the piston and necessitates removal.

Poor performance of different power assembly configurations evaluated in EMD tests generally was attributable to the presence of high levels of catalyst fines in the fuel. Unfortunately, 80% of the vary hard, abrasive particules present in the tests were found to range in size between 1 and 5 microns, and in this range, even special filtration is of little help.

Another significant effect of catalyst fines in the fuel is rapid deterioration of injector performance due to high plunger and bushing wear rates, as well as excessive spray tip orifice erosion. The resulting degradation in combustion performance results in extensive turbocharger nozzle deposits, Figure 11, and turbocharger surging.

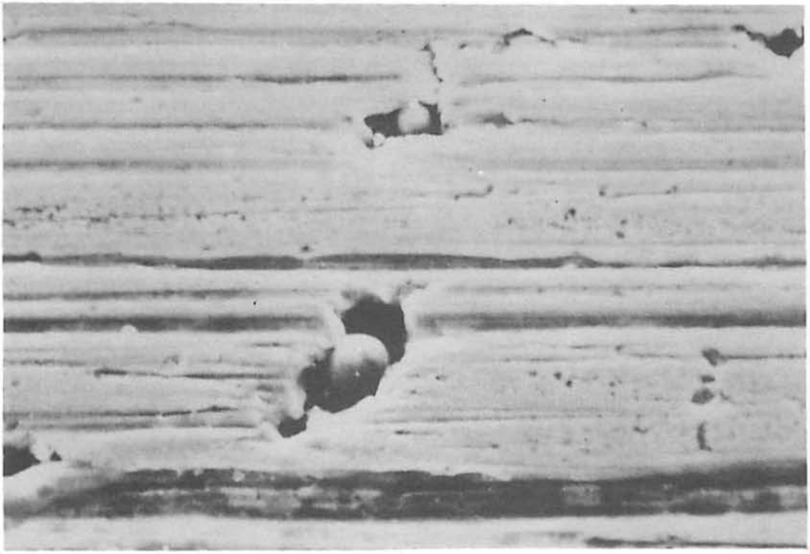
Vanadium

The presence of vanadium in the fuel, particularly in combination with the sodium and/or nickel, forms molten compounds when exposed to exhaust temperatures in the range of 1000 to 1600°F. These compounds promote intergranular corrosive attack of exhaust system materials as well as extremely hard adherent, oxide deposits which can affect exhaust valve performance and, in some instances, the turbocharger blading.

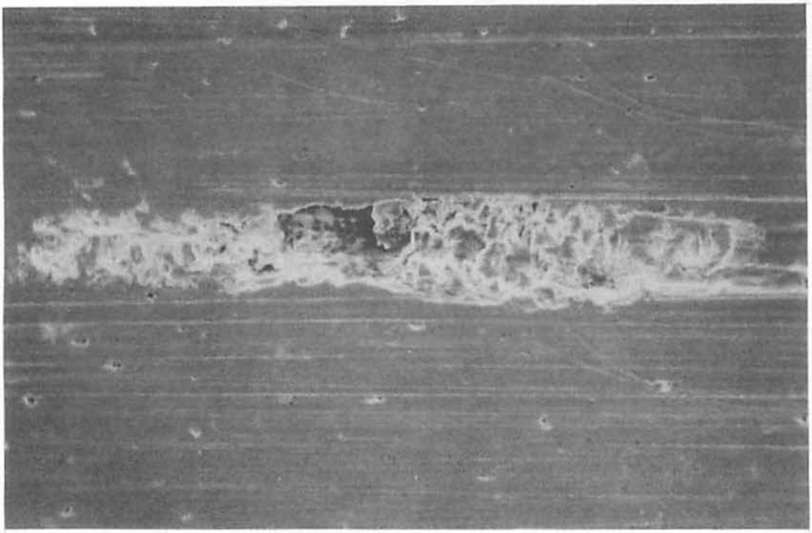
EMD valves shown in Figure 12 are examples of the deleterious effects of corrosive activity in the cup and stem-to-head radius of the exhaust valves when using fuel with vanadium content varying from 70 to 100 ppm. EMD tests have illustrated the relative sensitivity of the standard inconel exhaust valve to vanadium content in the fuel. Figure 13 compares the rapid deterioration of the valve as the vanadium content increases.

Carbon Residue

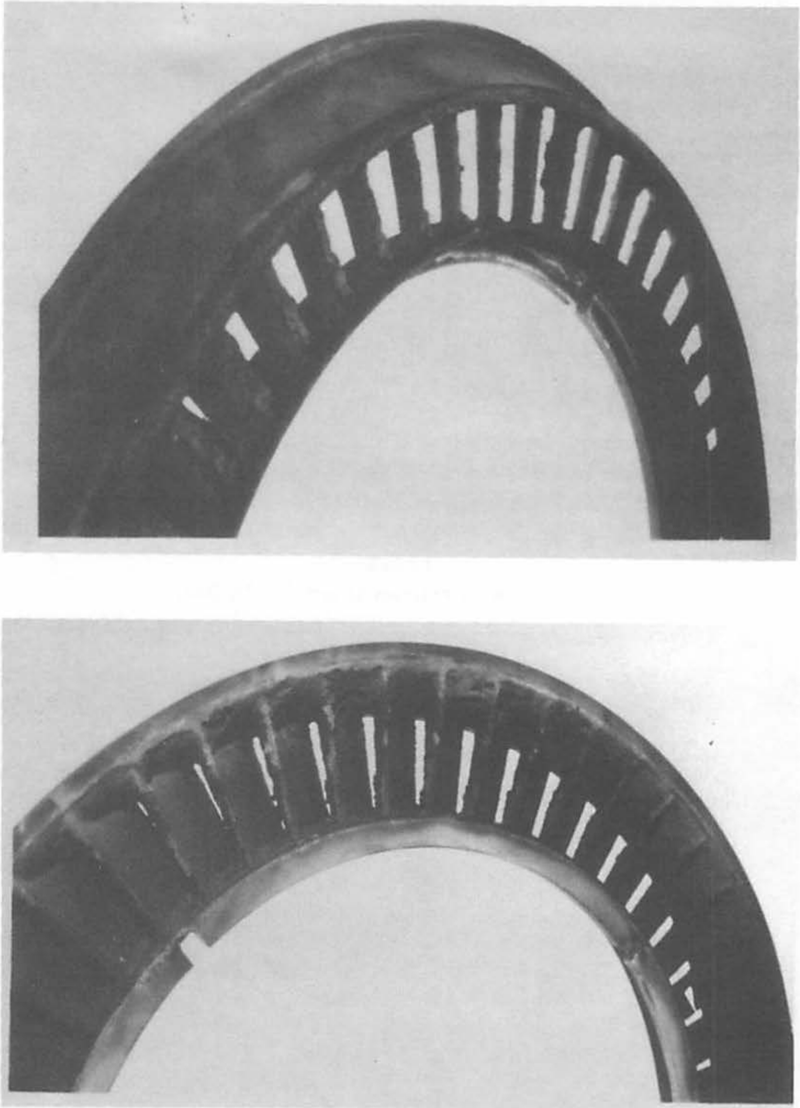
Carbon residue in blended fuels can have a pronounced effect on combustion chamber and exhaust system deposit levels. The residue is made up of both organic and inorganic materials which form adherent coke-like deposits, which can promote ring sticking, exhaust valve seating problems and exhaust system fouling. The long term influence of high fuel carbon residues has not yet been ascertained but acceptable performance appears feasible if levels are held to a reasonable value. Figure 14 illustrates deposit levels found in an engine run for approximately 900 hours on blended fuel. Deposits in the piston ring belt, cylinder head fireface, exhaust valve stems and exhaust system are relatively heavy compared to an engine operating on quality fuels. The deposits, however, are the direct result of the overall low quality of the fuel as well as the poor combustion resulting from deterioration of specific engine components.



1,000X
Fig. 9 — Two Particles Imbedded In Ring

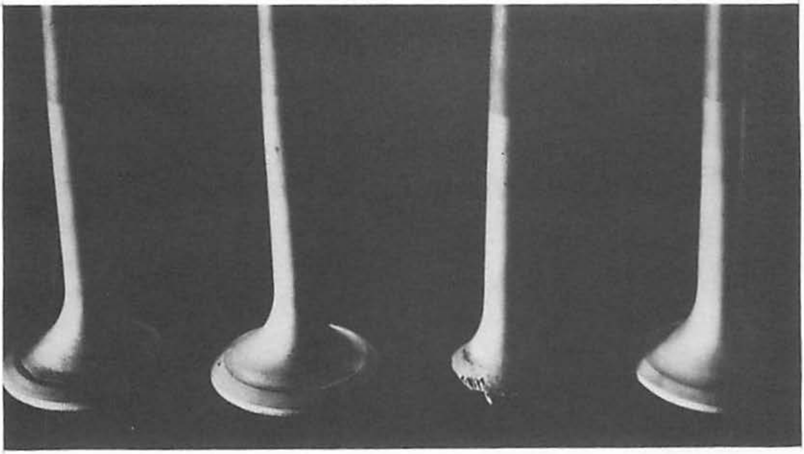


100X
Fig. 10 — Scuffing Resulting From Catalyst Fines



Fuel — 1.05% Sulfur, 115 PPM Vanadium, 200 SR1 Viscosity — 1053.1 Hours Operation

Fig. 11 — Turbine Nozzle Deposits



Fuel — 2% Sulfur, 100 PPM Vanadium, 1.6% Conradson Carbon
Fig. 12 — Exhaust Valve Failure Due To Vanadium Induced Corrosive Attack — Cylinder No. 6

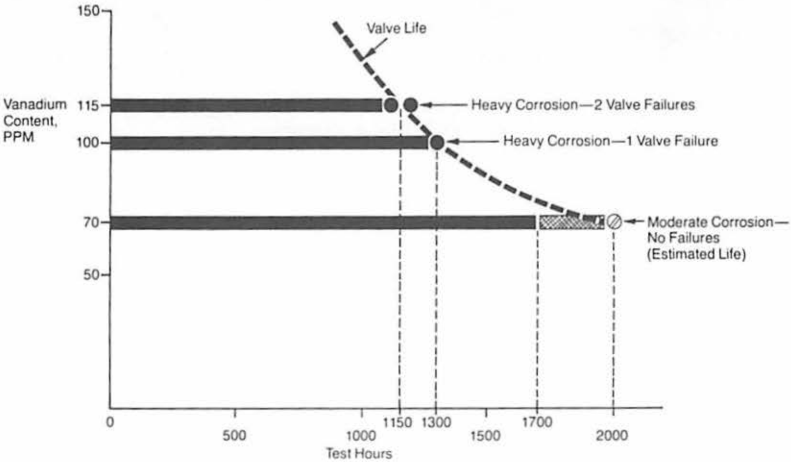


Fig. 13 — Exhaust Valve Response To Vanadium Content of Fuel

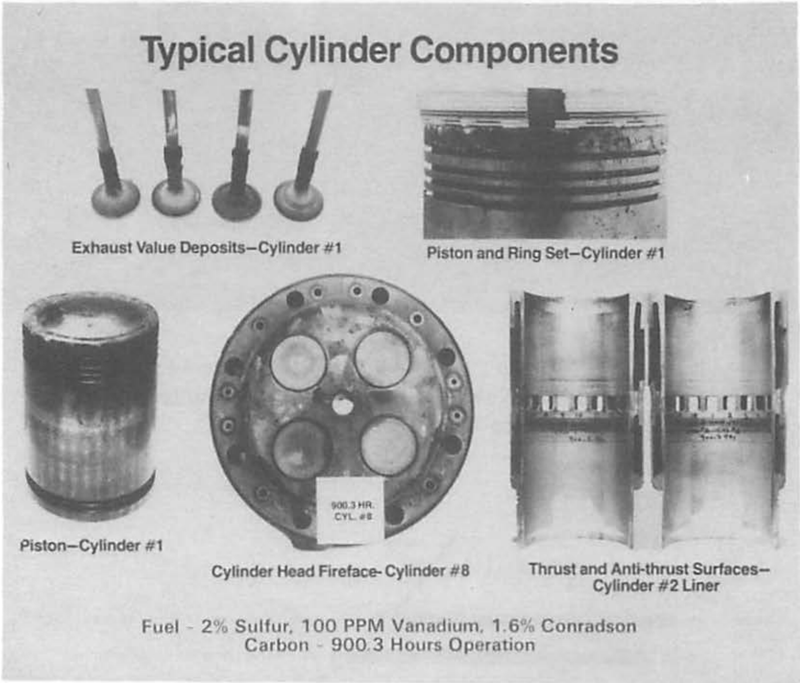
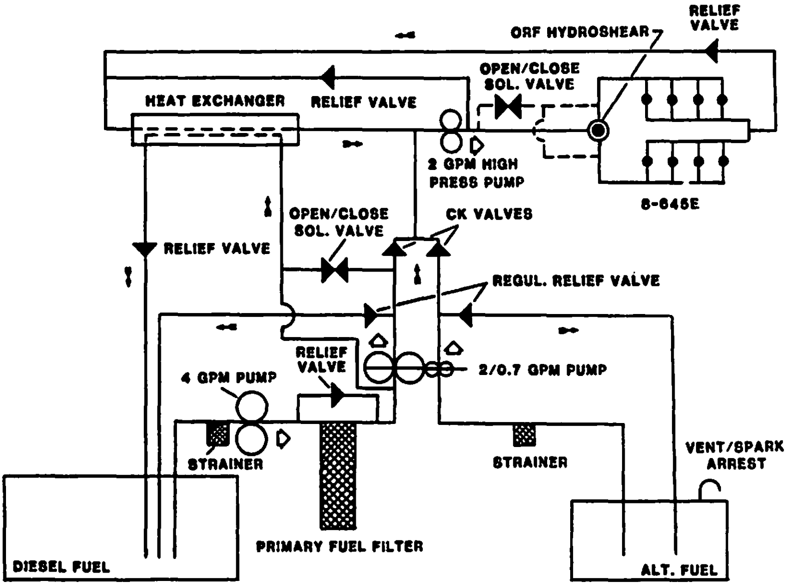

Typical Cylinder Components
Exhaust Value Deposits–Cylinder #1
Piston and Ring Set–Cylinder #1
Piston–Cylinder #1
900.3 HR.
CYL. #8
Cylinder Head Fireface- Cylinder #8
Thrust and Anti-thrust Surfaces–
Cylinder #2 Liner
Fuel - 2% Sulfur, 100 PPM Vanadium, 1.6% Conradson
Carbon - 900.3 Hours Operation

Figure 14



DIESEL/METHANOL SCHEMATIC

Figure 15

FUEL & LUBRICANTS COMMITTEE

Six-Year Index

1982

Quality Maintenance Thru Fuel and Lubricants

1. Energy Conserving Lube Oils
2. Alternative Fuels Update
3. Availability of Medium and High Viscosity Index Railroad Oils
4. Journal Box Oil and Aniline Point
5. Traction Motor Gear Lubricant Update
6. Traction Motor Gear Case Seals

1981

Problems, Solutions and New Techniques In Fuel and Lubrication

1. Effects of Using Alternate Fuels on Existing Diesel Engines
2. Update on Cold Weather Procedures for Fuels
3. New Techniques in Lube Oil Analyses
4. Traction Motor Gear Lubrication
5. Multi-Viscosity Oils as an Energy Conservation Technique

1980

Fuel and Lubricants — New Decade

1. High VI Diesel Engine Oil in the Railroad Industry
2. Assessment of Future Fuel Supply and Quality

1979

Fuel and Lubricant Innovations

1. Reclamation of Used Railroad Lube Oils
2. Reclamation of Chromate Water and Waste Oil
3. Effects of Engine Modifications on Fuel and Lube Oil
4. Air Compressor, Governor and the New AAR Journal Box Oils
5. New Spectroscopic Technique

1978

Problem Prevention Through Lubrication

1. New Energy Sources — The Race of Snails
2. Lube Oil Consumption Using Strontium 88 as a Tracer
3. Generation 4 Lubricating Oil — Performance Update
4. Locomotive Wheel Flange Lubricators
5. Discussion on the Use of Proper Lubricants

1977

Better Performance Thru Lubrication

1. Engine Lubricating Oil Developments
2. Progress in Spectrographic Analysis and Computer Data System
3. Other Lubrication — Air Compressor Oils, Synthetics and Traction Motor Greases
4. Fuel Additives
5. Methods of Measuring Lube and Fuel Oil Consumption

J. F. McDONOUGH
Chief Mechanical Officer
Union Pacific Railroad Co.
Omaha, Nebraska

R. P. NEELEY
General Mech. Supt.-Locomotive
Union Pacific Railroad Co.
Omaha, Nebraska

LMOA wishes to express its thanks to Union Pacific Railroad for again hosting Pre-convention Presentation in Omaha.

Our Diesel Electrical Maintenance Committee's presentation was well received in what we trust was a mutually beneficial experience.

Our thanks again to Messrs. J. F. McDonough and J. P. Neeley and others responsible for and participating in this activity.

Wednesday, September 21, 1983

8:30 A.M.

REPORT OF THE COMMITTEE ON DIESEL ELECTRICAL MAINTENANCE

Pre-Convention Presentation: Union Pacific Railroad

April 7, 1983 Red Lion Hotel Omaha, NE

J. KUZELA, JR., Chairman
Engineer Design
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VICE CHAIRMAN

K. R. Keller, Asst. General Foreman Locomotive, Burlington Northern Railroad, W. Burlington, Iowa

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K. M. Watkins	Supt. Electronic Systems	Amtrak	Washington, DC

1983 TOPIC:

"NEW SOLUTIONS TO LOCOMOTIVE ELECTRICAL PROBLEMS"

PERSONAL HISTORY

J. F. KUZELA

Born January 5, 1930 in Omaha, Nebraska. Attended public schools in Omaha and graduated from South High School, Omaha, NE. Member of U. S. Naval Air Reserve for eight years.

Joined the Union Pacific Railroad in 1946 as a Telegrapher, promoted to Electrical Helper and Carman in 1948, Electrician Apprentice in 1950, Electrician 1952, Electrical Foreman 1956, Supervisor of Oil, Gas, Electric and Motive Power 1969, General Supervisor of Oil, Gas, Electric and Motive Power 1972, Engineer Design-Electrical 1979.

Has been a member of the LMOA since 1956. Married to Betty Jean Rabb of Omaha on November 3, 1951. Has one daughter, Susan, and three sons, Steven, Joe and John.

GROUND RELAY TROUBLE SHOOTING

"Ground Relay Action" has for many years been an everyday concern for most railroads. The ground relay is a necessary component in a locomotive electrical system, its purpose being to protect the main generator, traction motors, and high-voltage wiring, and to reduce the possibilities of electrical fires.

Locomotive electrical systems have evolved over the years to become much more reliable and to perform duties that are very important to railroad operating efficiency.

"Transition Trouble" is a nagging problem that has been greatly reduced over the years and, in fact, eliminated on many classes of locomotives. Wheel-slip circuits have been greatly improved, but ground relay action continues to be troublesome.

Much effort has been put into the development of electrical components and systems to eliminate ground relay actions, and maintenance procedures can surely cut down on their frequency.

Some older classes of locomotives had traction motor blower motors located in areas where they would pick up oil leakage from the engine and related systems, and then blow the oil into the traction motors. This condition lead not only to ground relay action but adversely affected commutation, resulting in many short lived traction motors.

Since the filtered and pressurized air systems have been available on locomotives, the filth and oil has not been nearly as much of a problem as it was on older locomotives. However, some cleaning by hand is still recommended. A good practice for running repair facilities when inspecting traction motors is to wipe clean string bands and brush holder insulators.

Keeping these surfaces clean will prevent current leakage paths, which eventually become severe enough to cause "tracking" and then ground relay trip. By that time, the only way you can cure the problem is to replace the brush holder or string band. Replacing the string band, is very costly, because it requires, in most cases, removing the traction motor from the locomotive and then a tear down of the motor.

Teflon is a good creepage surface for string bands; epoxy will not resist dirt adhesion as well. Some railroads still prefer epoxy because teflon has been known to peel off; however, a seamless teflon band has been developed that eliminates the possibility of separation at a seam. This band has also been modified where it contacts the commutator bars in an attempt to prevent "peel back."

Another improvement is in carbody cabling. Carbody cabling has better insulation now and cabling also has been routed and clamped in such a way to facilitate easier maintenance. Grounds due to carbody lead to traction motor connector boots have been greatly reduced with the development of improved insulators and clamping methods.

One locomotive builder has eliminated the metal clamps in this area and allows the booted connectors to be suspended in free air. This method even further reduces the chance of grounds.

Many railroads have developed programs for commutator jigstoning to keep traction motor commutators round, and, therefore, decrease flashover related damage and ground relay action. The elimination of traction motor field shunting from modern locomotives has also improved commutation, and, therefore, decreased flashover related grounds.

With all the improvements over the years, why is ground relay action still here to bother us so often?

Studies conducted on several railroads indicate that the majority of the ground relay action problem points to the traction motor. Although better insulating materials are now used to keep conductors from going to ground, it would appear that probably there just isn't enough insulation used.

The railroads have identified the problem, and it is now a challenge for the builders to develop a motor that will give better performance.

Although not a cure for the problem, increasing the high voltage circuit leakage current at which the ground relay will trip is one method used by builders and railroads over the years to reduce on-line failures due to grounds.

Also, many railroads use automatic ground relay resets to keep the locomotive operating. The most common reset being three times before locking out.

Another method has been to reduce excitation proportionally to the leakage current.

One device even has an indicator light in the cab. The glow of light intensifies proportionately to the increase in ground leakage current and reduction in horsepower. Decreasing the horsepower, however, is not very popular, because like traction motor cutouts it is a crutch. People tend to take advantage of it by running crippled locomotives in this manner.

Other than improved components and improved electrical systems design, the most important thing is preventative maintenance and, of course, troubleshooting. Troubleshooting methods and thoroughness play a very important role. A thorough understanding of the conditions to look for is important. Proper tools, including meters and test equipment, are necessary.

Locomotive builders and most railroads have maintenance instructions written that are very helpful to those performing the task of locating the circuit components causing the ground relay action. Remember, it is those causes of failure that do not stare you right in the face that are difficult to find and are the repeaters of on-line failures. On-line failures, of course, are very costly, and to be avoided.

When a cause of ground relay action cannot be readily identified, the person conducting the search must then be ready with a wealth of knowledge and experience to search out the problems.

Items to watch for when troubleshooting a locomotive that has been reported for ground relay include the following:

—Megger or ohmeter reading will locate the most obvious grounds.

—AC or low voltage control circuits bleeding into (shorted to) the high voltage circuits. This is why locomotives service manuals' instructions are to ground the low voltage and AC circuits when making Hi-Pot Tests.

(Caution must be exercised not to use excessive test voltages on low voltage and AC circuit equipment.)

—Brush related problems—broken, stuck, short, defective shunts.

—Flashovers will carry electrical current to ground sometimes causing the ground relay to trip. A motor that has been flashed is easily identified by the damage caused. (Jig-stoning may be required.)

—Chafing of improperly secured cabling to traction motors.

—Defective contactors, resistors, relays and devices in the high voltage circuits.

—Phase-balance protection circuit —Ground relay circuits on some model locomotives are wired to also recognize phase imbalance of the alternator.

—Transition problems — Incorrect settings can cause voltage spikes when switch gear transfers.

—Housecleaning — Generally, clean equipment will reduce the frequency of ground relay action. It is recognized that electrical currents will "track" across insulation materials, such as brushholder insulators, string bands, terminal boards, connectors, and all such areas where foreign material is allowed to accumulate.

—Drain and generator pit aspirators must be kept clean and open to prevent accumulation of water and oil.

—Moisture grounds — Sometimes moisture is suspected to be the cause of the ground relay action.

Recommendations

Use an ohmeter to locate obvious grounds; then to further evaluate strength of insulation, use a 500 volt or 1000 volt megger.

A DC Hi-Pot can be used to simulate test voltages similar to voltages to which insulation is subjected during locomotive operation. Use of a DC Hi-Pot at greater than 1500 volts causes a serious risk of damaging insulation.

It is recommended that the destructive AC Hi-Pot only be used after all else has failed to expose the problem area, and then, only on an isolated piece of suspected electrical equipment. Caution must be exercised while using high potential testers to protect personnel from electrical shock.

Moisture Test

A simple test using a voltmeter with a low range scale can indicate moisture content of the insulation in motors and generators.

Motors and generators are made of two dissimilar metals (copper and iron); and when separated by wet insulation, a battery is formed, generating a voltage. The voltage present can be found by placing the voltmeter leads, one to ground and the other to the copper conductors of the motor or generator.

A voltmeter of .5 volts or less can be expected to be generated from a wet electrical component.

If no voltage is present, application of heat to that component will not help to increase the megger reading or decrease leakage current. If a voltage is present, heat can be applied to dry out the motor or generator, and megger readings will improve after the component has dried out and cooled. Leakage current will also be reduced when testing with Hi-Pot.

Sometimes, after all else has failed, it is necessary to dispatch the locomotive again for observation so that the ground, if still present, can develop to a detectable level. This will prevent unnecessary changeout of good components.

There is an increasing interest in on-board monitoring systems for locomotives. At least one vendor has a method of indicating and recording traction motor flashover in their monitoring system. In addition to this, it would be most helpful if total high-voltage leakage current to ground was recorded during locomotive operation.

The ultimate analyzer would be a monitor system that could record not only total high-voltage circuit leakage current, but also record leakage from each individual traction motor during locomotive operation.

TRACTION MOTORS

On many, if not all railways, the traction motor is the largest contributor to the maintenance costs of a locomotive electrical system. Of all the electrical components of a diesel electric locomotive, it deserves and probably gets more attention than any other part. We are constantly investigating our traction motor failures. But an impressive display of charts, tables and graphs does not cure the illness. Once the symptoms are identified, one must take positive action to help the sick.

Two years ago, a study of traction motor performance during the last twelve years showed a very strong relationshi p between the average age of the traction motor population and the failure rate expressed in percent of motors in service. The results are summarized in Figure No. 1. There is perhaps nothing surprising about the results, but how do we end up with a motor population that old?

Traction motors are orphans, they are not married to any locomotive. Because of numerous failures and also wheel changeouts, motors are constantly displaced from one locomotive to another. When a locomotive is retired, many railways will salage expensive components to build up a pool of spare parts. Therefore, we still find on the property quite a few motors that were built 30 years ago and came to the scene under F-3's, F-7's, and other first generation locomotives.

One obvious conclusion of that study was that if we could bring down the average age of our traction motor population, hopefully the failure curve would decline, and motor reliability would improve. How do we accomplish that? One possibility is to scrap old motors and buy new ones to replace them. The alternative is to renew all the components subjected to wear and tear, bring all the mechanical dimensions to "new" tolerances. This

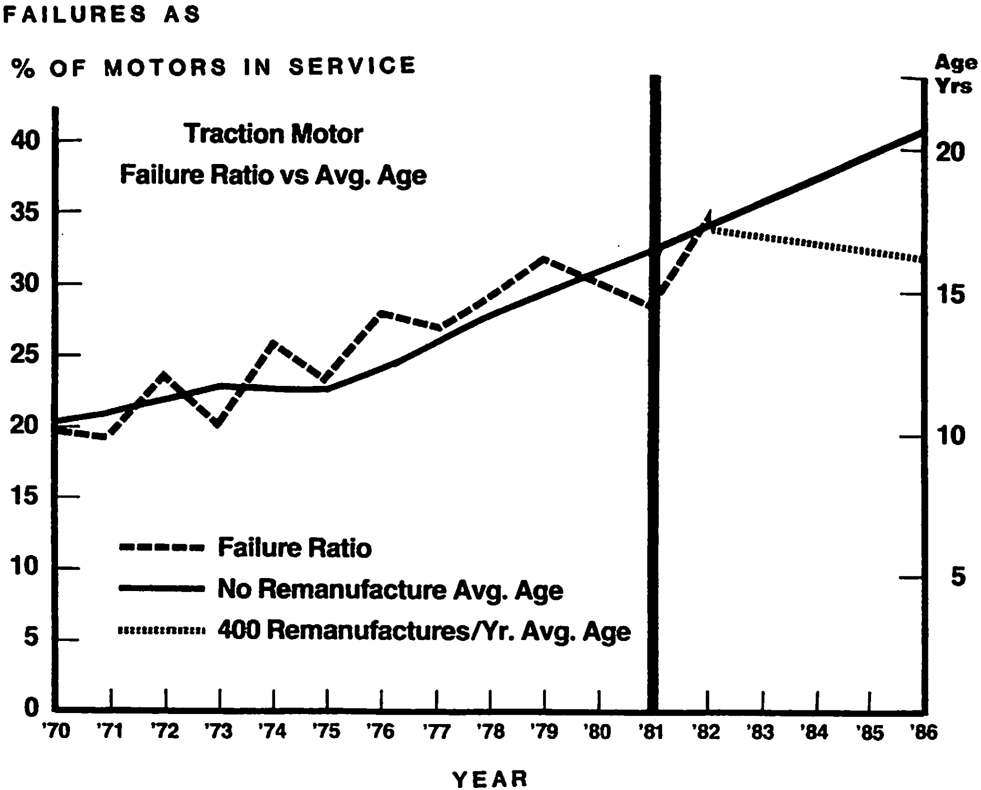

FAILURES AS
% OF MOTORS IN SERVICE
Traction Motor
Failure Ratio vs Avg. Age
Age
Yrs
40
35
30
25
20
15
10
5
0
20
15
10
5
Failure Ratio
No Remanufacture Avg. Age
400 Remanufactures/Yr. Avg. Age
'70
'71
'72
'73
'74
'75
'76
'77
'78
'79
'80
'81
'82
'83
'84
'85
'86
YEAR

FIG. 1

can be done in various outside shops across the country, or in the railway shops. In difficult times, the railways may want to retain as much work as possible for their own employees. This article attempts to describe the first experience of a railway at remanufacturing traction motors. The goal is to produce a motor that is as good as a new motor purchased from the original builder (in this case, EMD), but do it for less money.

Since the newest traction motor available from the Electro Motive Division (EMD) is the D-87, it was decided to remanufacture the old frames with D-87 coils. Numerous consultations took place between the railway, EMD and GM Canada (Diesel Division). Since we had no maintenance instruction to cover the particularities of the D-87 motor, we ran into various snags and problems.

In this project, we decided to use D-77 armatures in the D-87 frames. We felt the operating conditions in the snow country did not warrant the extra cost of the D-87 armature. However, we were still interested in evaluating the true D-87 motor, that is, with a D-87 armature. Therefore we purchased from General Motors 18 new D-87 motors in 1981 and 25 new D-87 motors in 1982. These motors were built in La Grange.

Other railways are trying a different combination by applying a D-87 armature in a regular D-77 frame. Hopefully, at some time in the future we will have enough statistical information to comment on the relative merits of each approach.

The following procedure describes the various steps of a D-87 frame remanufacturing program and highlights the differences between the D-77 and the D-87 rebuilding practices. It was written to be used in conjunction with M. I. No. 3950, Revision "B" for sections 1 to 5, Revision "C" for sections 6 and 7. These revisions are all dated January 1978. We understand that a new revision will be published as soon as possible by EMD to include the particular feature of the D-87 motor. Until it is published, the following procedure should be helpful in the repairing of D-87 motors or upgrading older frames to D-87 standards.

SPECIFICATION FOR REMANUFACTURING D-87 TRACTION MOTOR FRAMES (Using D-77 Armature Coils)

General

This specification concerns procedures to be followed on receipt of EMD traction motors that require an obvious rebuild (basket cases, bird's nests, bad bearing failures, armatures that disintegrated, and so on...), and also old motors (20-25 year old) that still have their original field coils. In particular, any D-27, D-37 motor is a prime candidate for this program. A D-47 motor that has been dipped several times will be remanufactured if the air passages between baffles are blocked solid with varnish.

Stripping and Cleaning

Stator frames and caps are thoroughly cleaned and grit blasted after coils have been removed, using 0.023" steel shot available from Wheelabrator.

Mechanical Frame Restoring

1. Welding
   All bores, faces and splines are completely Mig-welded using "Cayuga" (Buffalo) automatic welding equipment. All brush-holder pads are removed.
2. Axle Caps
   Wide window caps are scrapped and replaced with the latest style narrow window type. Each gearcase support arm is magnetic particle tested for cracks, and repaired if necessary.
3. Stress Relieving
   After all welding and burning is complete, the frames and caps are annealed in a furnace. Maintain a temperature of 1175°F for two hours after the frame reaches that temperature.
4. Machining
   All machining dimensions are restored to "NEW" tolerances as per EMD Maintenance Instructions No. 3950, Section 3. The machining is performed on a numerically controlled (NC) programmable boring mill, which is supplied by Giddings and Lewis of Fond du Lac, Wisconsin. The main references for the whole machining process are:

   Photo 1

   a) Centerline of armature bearing bore same as electrical centerline. This is achieved by using a mandrel with retractable legs to position the frame precisely on the machine table. Interchangeable pallets are used so that a frame can be machined while another one is being positioned.

   Photo 2

   b) Distance between first main field bolt hole (nearest to commutator end) on the axle side and inside face of commutator end armature bearing bore: 18.063" ± 0.015".
5. Shimming of pole and coil seats
   To achieve the proper armature air gap, the pole and coil seats are machined if necessary. In some cases the main pole seats are machined oversize and shims are applied—.058" - .060" standard sheet metal. The shims are tack welded to the frame.
   Reference=EMD drawing No. 9336702.
6. Application of brushholder pads
   Brushholder pad seats are machined parallel. The pads are positioned with an EMD special fixture No. G-59262, and welded in place.

   Photo 3
7. Cleaning and Painting
   Remove burrs, pieces of welds, and cuttings from the main field and interpole coil pads. Paint the interior of the frame

Photo 1

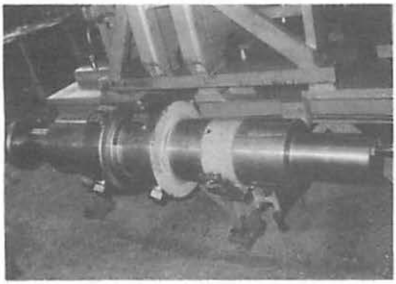


Photo 2

with Orange epoxy Glyptol insulating paint.

Caution: Do not paint the coil and pole seats. The paint would insulate the baffles from the frame, and they will start arcing when AC hi-pot test is performed.

8. Electrical Frame Rebuild
   To apply and align the coils, use instructions in MI No. 3950. However, do not take dimensions from the MI. There are differences in dimensions between a D-77 and a D-87 frame —air gaps for example.
   a) Apply axle cap simulator at the pinion end prior to assembly of coils. The simulator should remain in position until the armature has been assembled in the frame, in order to prevent distortion of the frame during coil application.
      Reference: Axle cap simulator: EMD File No. 888
      Photo 4
   b) Place the frame in a stator turnover stand.
   c) Block through hole on baffle at each end with RTV

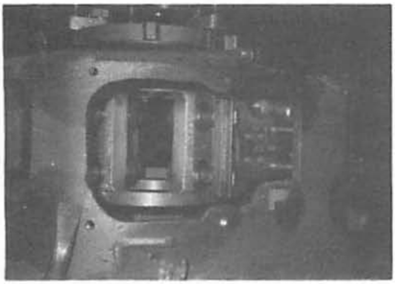


Photo 3

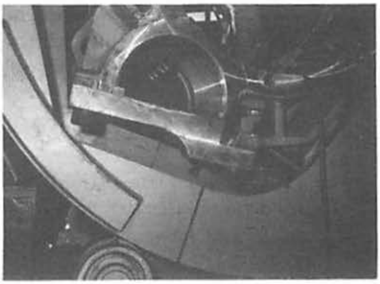


Photo 4

(Silicone Rubber Compound). Stick the baffle to the bottom of the main field coil with RTV. Apply a 4"x6" piece of Nomex at the pinion end of the axle side coil, use RTV for adhesive. This will prevent grounds caused by chaffing at the lead and front end.

d) Apply No. 4 main field using special lifting device and two guide pins. (Pins only used on No. 4 field).
All bolts and studs must be lubricated with Texaco Threadtex.
All torquing must follow torquing procedures. (See torquing procedures, item No. 9).

e) Apply Nos. 1, 2, 3 main fields and tighten with torque control pneumatic wrench only (see torquing procedures, item No. 9).

f) Check air gap using inside mikes (18.655" - 18.705"). It is important that the measurements be taken between the two bolt holes at each end. If shimming is necessary, use .005" and .010" shims between the coil shield and pole, at the sides for the full length and width.
Retorque and Megger Test coils at 1000v.

g) Apply No. 4 main field line up bridge. Rotate turnover table and loosen No. 4 main field. Jack coil into position and check with lineup pins. Torque No. 4 main field. (See torquing procedures Items No. 9). Rotate table for No. 3 main field alignment.
*Note:—never loosen No. 4 main field after alignment.

h) Remove No. 4 line up bridge and start coil spacing. Main field Nos. 3-2-1 are spaced in relation to the No. 4 main field using a gauge and jack. The maximum variation between all poles is .030". (Master block gauge D-87 4.8900", actual size, No. 9317625). Torque all (see torquing procedures item No. 9). Megger test coils at 1000v.

i) Apply and braze leads using bending bar to ensure that leads are parallel for a 100 percent brazed joint. Use Harris "stay-ZIL ZLP" brazing rod.
Note: Quench brazed joints with water.

j) Prepare interpoles by brazing the proper lead to one side of the IP connection and tape.
Note: Quench brazed joints with water.
No. 1 Bottom suspension with "AA" lead.
No. 2 Top suspension with jumper.
No. 3 Top axle with jumper.
No. 4 Bottom axle with brushholder cross jumper.
Apply fibre washer with .020" stick on shims on

each side of washer. Check the number on the pole piece and apply the same number of stainless steel washers. Use adhesive glass tape to secure washer for application. Apply pole piece shims (for air gap), one steel and one aluminum on top. (See figure No. 2)

Fig. 2

k) Apply interpoles using IP lifting device and dummy studs. (Sequence No. 2-1-4-3).
Torque all (see torquing procedures item No. 9).

l) Check interpole air gap at each end with inside mikes (18.822" - 18.847"). Too much gap: apply another stainless steel shim under the aluminum one and add another stainless steel washer on top of the fibre washer. Not enough gap: Remove interpole and check for burrs, weld, etc.
Remove one (1) only stainless shim, and one (1) only stainless washer.
Do not remove stainless shim if coil does not have a stainless washer.

m) Align interpoles using gauge and jack.
*Note: Do not disturb main field coils when spacing interpoles.

n) Torque all interpole bolts. (See torquing procedures item No. 9). Megger test coils at 1000v.

o) Braze and tape all connections.
Note: Quench brazed joints with water.

p) Hipot stator at 3500 VAC for one minute.

q) Resistance checks:
Main Field Circuit:
.00776 - .00808 ohm at 75°C
or .006671 ± 2% at room temperature.
Commutating Field Circuit=
.00607 - .00632 ohm at 75°C
or .005255 ± 2% at room temperature.

r) Surge test (use PJ tester) at 7000 VAC two (2) to two (2) coils 3500 VAC one (1) to one (1) coil..

s) Tie all cables using resi-glass cord.

9. Torquing Procedures
All main fields must be torqued to 600-700 ft.-lbs. except No. 4 main field.
Torque No. 4 main field to 600 ft.-lbs. then loosen and retorque to 300-325 ft.-lbs.
All interpoles must be torqued to 400-450 ft-lbs. Caution—do not torque to 600-700 ft.-lbs. or the pole pieces will be damaged.
All bolts and studs must be torqued in proper sequence from comm. end 1-4-2-3 (Ref. MI 3950-4 page 15).

10. Armatures
Rewind the armature with a D-77 winding kit, a new or rebuilt commutator, a new D-87 shaft and a new end bell hous-

D-87 INTERPOLE COIL SHIMMING

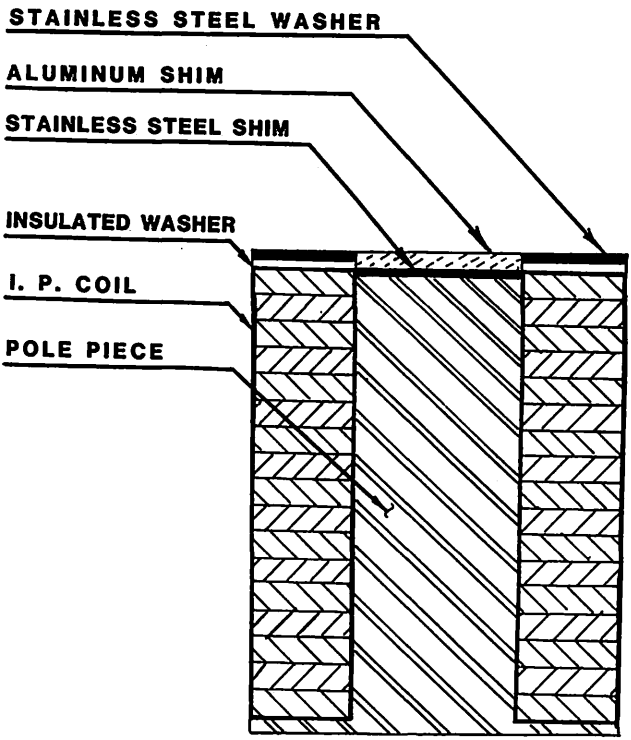


FIG. 2

ing. Any core failing the core loss test (175 amperes at 8 volts) must be scrapped and replaced by a new one.

Photo 5

Reference for core loss test: 1980 LMOA book, page 268.

Armature must be double Vacuum Pressure Impregnated and dipped once in solvent type polyester varnish.

Teflon band is to be applied to the builder's latest specifications.

The commutator slots are to be cleaned of side mica and deburred. This can be accomplished by using a GM deburring tool (No. 8270339). Risers must be cleaned from carbon.

*Note: Under no conditions are commutator bars to be chamfered. Commutators are to have a final turning using a diamond tool.

11. Mechanical Assembly Parts
Inspection and reclamation of mechanical parts to be in accordance with MI3950, Section 2.
Note: This applies to commutator end components only.

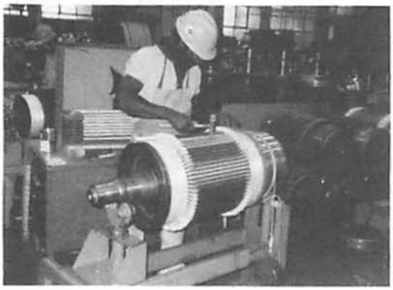


Photo 5

All mechanical parts at the pinion end are new to accommodate the larger 150 mm bearing.

12. Bearing Application
All bearings are to be assembled to the housing by a press method (no freezing).
The amount of grease applied to the pinion end is 41 oz. (MI 3900). It should be formed using the proper grease masks (No. 9531317 for cover, 9529867 for cap PE).
Amount of grease and grease masks at CE are same as D-77. (Ref. Grease and bearing application MI 3950-7).

13. Pinion Application
The advance for the D-87 pinion is greater than for the D-77. It is necessary to heat the pinion approximately 189°C or 340°F above shaft temperature.
Pinion advance — D-87 —
2.16 mm ± 0.13 mm
or 0.085" ± 0.005"
Ref. EMD MI 3900 Revision F pages 30-32, also page 37.
Caution: Pinion temperature should never exceed 232°C or 450°F.
Note: MI 3950-7 page 15 indicates that pinion temperature should not exceed 190°C or 374°F. We understand that these figures will be changed in the next revision of MI 3950.

Photo 6

14. Testing
All remanufactured motors are to be final tested on the Becker tester. Reference: General

Photo 6

Electric (Cleveland, Ohio) test Console Model GE-TMC-42377.

15. Name Plates
    New name plates are applied and new serial numbers are assigned to the motors.

LOCOMOTIVE STORAGE (Electrical)

A survey by this committee concerning procedures for storing diesel locomotives indicate builder recommendations are followed very closely. However, GE's GEK-612-40A and EMD's MI 1726 apply to locomotives to be stored for several months.

The fluctuation of business over the past two years has required locomotive maintenance officers to issue specific instructions for storing locomotives for various lengths of time and also be ready to handle increased business with a minimum amount of delay and maintenance expense.

Some of the categories used for storing locomotives are as follows:

1. Hold or temporary storage.
2. Short-term storage — warm or cold climate.
3. Long-term storage — warm or cold climate.
4. Stored — unserviceable.

"Hold or temporary storage" would apply to locomotives out of service due to a temporary decline in business that may result in locomotives being shut down from one to two weeks. Preparation for this type of storage would only require opening all switches and circuit breakers. We do recommend starting the engines once each week and run approximately four hours to maintain the battery charge. Open all switches and circuit breakers after each start-up. The diesel engines must not be shut down when ambient temperature is expected to drop below 40 degrees F during the duration of shutdown unless they are equipped with a low-temperature protection system.

"Short-term storage" preparation would apply to locomotives out of service for ninety days or less. Here again, procedures used for storing locomotives will vary due to climatic conditions throughout the country. The most important item to check and maintain in this type of storage is the batteries. The liquid level must be checked and specific gravity reading recorded. If below 1.220 reading, batteries must be charged to insure maximum cranking capacity and eliminate the possibility of freeze damage during the ninety day storage period.

Cleanse top of batteries with soda solution and rinse with clean water to prevent batteries from discharging prematurely. Coat carbody battery cable terminals with cable corrosion inhibitor or petroleum jelly. Remove trainline jumper cables and store inside cab.

Railroads that have locomotives stored in areas that have high humidity are seeing corrosion and rusting on electrical component parts at this time and you may find it necessary to use two or three one-lb. bags of desiccant in the high and low voltage compartments, including the module compartments. Coating of all movable and stationary contacts with a light film of petroleum jelly or approved lubricant spray will also control this type of contamination.

"Long-term storage" applies to locomotives that will be in storage for a period of ninety days or more. If at all possible, these units should be stored at locations where maintenance personnel are located and away from locations that have high humidity. This type of storage will require special attention to all AC and DC rotating equipment, high and low-voltage electrical cabinets along with the removal of the batteries where temperatures drop below freezing.

An insulation test should be made to the high and low-voltage system using a megohmmeter, just prior to storage and the reading recorded. Open all switches and circuit breakers. Remove all DC and AC carbon brushes and place in suitable containers for protection and store in cab. (It is noted that one railroad and GE recommend brushes be removed from the brushholders and left suspended or hanging free of the commutators.) Cover all fan openings in roof. Cover the dynamic brake grid screens, traction motor vents on pinion end, air inlets of the traction motor, and generator blowers. Use one-lb. bags of desiccant in all builder recommended areas. Indicator cards should be used with desiccant bags, and inspection made of the color periodically. These bags and cards should be renewed if the color of the card so indicates. The engine governor, electric starting motors, and load regulator should be wrapped with a water vapor-proof material or plastic wrap and secured with pressure sensitive tape. The electrically operated speed recorders, which use magnetic tapes for monitoring various functions of the locomotive, must be protected for long-term storage. Removal of the tapes and a dehydrating agent applied in the recorder would be recommended. It is noted that GE does not recommend using a silica gel or other dehydrating agents when storing locomotives. However, GE does suggest protecting traction motors and generators from direct weather abuse by using an "umbrella" or shield where blowing rain, sand or dirt may enter.

One railroad that stores locomotives in a cold climate requires traction motors and main generators to be completely covered with plastic wrap and secured with pressure sensitive tape.

The vapor phase inhibitor paper (VPI) used to protect other areas of the locomotive must not be used inside of engine or electrical equipment. VPI causes copper and zinc discoloration and also causes silicone seals to harden and take a permanent set.

"Stored unserviceable" units must not be overlooked. These locomotives may require heavy engine repairs, fire damage or accident repairs or meet a cost criteria set by your operating appropriations not to repair. Normally, these locomotives are stored in the lower forty somewhere awaiting shop space or money to repair. However, they must be prepared in the same manner as long-term storage.

These locomotives should be inspected and a report prepared giving condition at the time of storage. Due to cannibalizing of parts from this type of stored unit, this report should later show any parts "borrowed" and material reordered immediately if unit is to be returned to service. Having material on hand will help reduce downtime when restoring several locomotives to service immediately.

Batteries removed from locomotives scheduled for long-term storage must be stored in a protected area kept above freezing temperatures. The batteries should be checked and recharged at least every three months (specific gravity 1.250-1.275) or more often if experience dictates. Coat all battery cables with corrosion inhibitor or petroleum jelly. If units are stored in warm climates, it may not be necessary to remove the batteries where trainline or portable systems are available to recharge them.

Batteries should be cleaned with a soda solution and rinsed with clean water to prevent batteries from discharging prematurely.

Due to batteries being a high cost budget item, accurate records must be kept, as to locomotive removed from, type of battery, ampere-hour rating, age and condition when received at the location of storage.

By grouping batteries in age and capacity sets, we can mix and match when one tray or cell indicates a gravity adjustment is needed or a thorough freshening charge. When cracked trays are found, terminal post burned off, or cell cap holes broken, we can again mix and match trays of equal faults. After necessary repairs are made, trays can then be grouped with like trays until a complete set is made.

When qualified sets are ready for service, they can be used in place of buying new. It must be remembered that this type of borrowing from your battery pool will catch up with you should there be a sudden increase in business and every railroad in the United States is trying to buy batteries.

We must record all batteries that are scrapped and not replaced with new. Although immediate replacement may not be required, you can advise those who make budgets and appropriate the money what your requirements will be to get the fleet back in service. Another way to help the battery pool is to buy dry-charged batteries and store until needed. To prepare for use, add electrolyte of 1.230 specific gravity to each cell, and charge batteries until the specific gravity stabilizes at 1.240-1.250 corrected for temperature level.

We hear many old wives tales concerning batteries discharging when stored on concrete floors. Battery builders have been asked this question, and to date our only answer is batteries will not discharge when left on a concrete floor provided they are thoroughly clean externally.

One railroad reports using a rotation or cycling system for returning stored locomotives to service. Locomotives that have been stored for six months are made ready for service and a like total of locomotives are selected to replace them in storage.

This system was established when it was learned that 25 percent of the units that were stored for six months or more had encountered trouble with the batteries when returned to service. In some cases the battery was a total loss. Other sets required replacement of from one to four trays, with the remaining trays of these sets being prime candidates for premature failures.

Time studies for placing locomotives in storage and taking them out should be made, recording all malfunctions. Analysis of these malfunctions will reveal whether most were caused by too long a storage period. If so, there may be justification for rotating locomotives in and out of storage for shorter periods of time.

Periodic inspections must be made on your stored locomotives to determine the lasting qualities of storage preparation. EMD recommends that equipment stored over two years have all preparations for storage repeated. GE recommends that stored locomotives be reactivated once each year and the process repeated.

We did not get into the labor and material cost for the different types of storage because instructions issued will vary when locomotives are stored in warm or cold climates.

Water Cooling & Refrigerating Methods For Locomotive Cab Application—What Direction Should Be Pursued?

The rail industry has searched over the years for a cost effective and reliable system for providing sanitary, adequately cooled water for train crews on board locomotives. This has been no easy task.

Most locomotives to date have been equipped with water coolers and refrigerators using primarily six basic systems for obtaining a cooling effect. One system uses direct current providing power to a DC motor that drives a belt-driven compressor. A second type of cooling system makes use of an alternating current source to power an AC motor for compressor operation. The third type is a direct current system employing a solid state device to obtain a cooling effect. As information, the solid state device just referred to is not a block of ice. A fourth, the absorption-type cooling unit, employs liquid circulation consisting of a charge of ammonia, water, and hydrogen applied to a boiler system. The fifth system features a simple vortex chamber and controlling the flow of compressed air. Last, a sixth system derives its cooling effect from direct application of ice to some form of insulated compartment or chest.

Since the advent of locomotive water cooling and refrigerating systems, an open compressor method has been in wide use and appeared effective. But as times changed, more and more emphasis was placed on the need for a system with much lower maintenance cost. Such items as belts, fans, valves, motors, compressors and gases with this system are maintenance prone, thus the development of a system to obtain the desired cooling without the high maintenance components just mentioned.

Refrigeration units equipped with a vortex cooling device appeared to offer a sound alternative to the open compressor system. Use of this system eliminated high-maintenance components.

Air under pressure is admitted into a refrigerating tube through jet like openings in the tube wall. These openings are arranged to make air spin in the tube, creating a vortex. The air on the outside of the vortex picks up the heat from the air in the center, lowering its temperature. This outside wall of heated air is then vented away. The chilled central core of air is used for cooling purposes.

Such a cooler in locomotive service would cease operating if the vortex tube became plugged because of a contaminated air supply. Although filtration was attempted, inherent moisture and oil associated with the locomotive air system would eventually plug the vortex tube, disabling the unit. Another problem was crew complaints of unpleasant odor and noise generated from the vortex tube discharge air. In some modes of operation, the volume of cooler operating air dissipated would deplete the locomotive main reservoir air supply, and the mechanical energy requirement for recovering the consumed air was considered to be cost excessive. Although sound in operating principle, vortex tube cooling units did not prove practical for locomotive application.

Continuous absorption-type cooling units operate by application of a controlled amount of heat furnished by gas, kerosene or electricity. No moving parts are employed. The absorption refrigeration system consists of four main parts—the boiler, condenser, evaporator and absorber.

The refrigerant charge consists of a quantity of ammonia, water and hydrogen at a sufficient pressure to condense the ammonia at the desired operating temperature for which the unit is designed.

When designed for operations with an electrical power source, as in locomotive applications, electrical current is applied to a heating element. The heating element supplies heat to the boiler system, which is the key element in the absorption process from which the desired cooling effect is obtained.

The refrigerator in locomotive cab applications provided inadequate service. One major component failure was the boiler heating element. Another prime area of concern was the compartment door latch and hinge hardware. This equipment did not prove able to withstand the amount of door closing and opening involved with routine locomotive crew usage.

If the absorption-type refrigerator were available in a more rugged package enabling it to live in tough railroad surroundings, it could prove to be a workable alternative.

Refrigerators designed with an alternating current motor-driven compressor are available in single and three-phase models for use on locomotives. Equipped with sealed or rechargeable freon refrigerant systems and compressor, it requires less maintenance than the direct current counterpart, and elimination of all belts is possible. However, attempts at providing an AC source by utilizing inversion techniques for inverting the locomotive

74 volt DC supply has proven unsuccessful. The inverting systems were unable to survive the harsh electrical realities of diesel electric locomotive service, requiring direct electrical connection to the locomotive's AC supply.

One hermetically sealed refrigeration system is considered to be unserviceable in the field. It features a convection cooled condenser and water dispensing system in which the water is packaged in shatter proof containers and never comes in direct contact with any cooler surfaces when dispensed for drinking. Installation requires mounting a bracket in one of the locomotive cab walls that conforms to the clean cab concept.

The above mentioned system was originally designed for household or office use and appears to satisfy some railroads. This cooler does not have the rugged construction design associated with railroad applications but offers a low purchase price.

Whenever ice is provided at service track facilities for application to an insulated compartment or chest, problems arise; this method has generally proved inadequate. Maintenance of ice producing equipment is a factor because an equipment failure will necessitate obtaining an alternate source of ice. Ice producing equipment at service track facilities have the same high-maintenance components associated with compressor systems, namely, belts, fans, valves, motors, compressors and gases. For practical reasons, the device for producing ice is located in an area other than the cab of the locomotive, typically a ready track building. At this building a sanitary environment is required and the ice must be transported from the ice machine to the locomotive cab. In the locomotive cab it must be properly dispensed in the cooling device. If the system requires that ice be in direct contact with the article being cooled, there is question as to whether or not this method will meet all necessary sanitary requirements.

Water from melting ice must be properly disposed of. This means provision for adequately draining of the water. If allowed to collect, the result is an unsanitary environment. Also, if the water leaked onto the cab floor, creating a slippery condition, there would be a safety hazard for crew members.

A Solid State Refrigeration Alternative

A recent arrival on the market and in limited usage is the Model RR-3 Bilan Solid State Refrigerator. A patented device, this unit has absolutely no moving parts. Making use of the thermoelectric principle and employing thermoelectric devices for cooling make it a completely solid state assembly without compressor, motor, gas, liquid or fan. Measuring 45" high by. 17½" wide and 14" deep, it is anchored by four base bolts to the locomotive cab floor.

Operating on standard 74 volt DC locomotive voltage, this unit is capable of cooling at the standard rate of 1.5 minutes per °F, with capability of lowering cooling compartment temperature to 65°F below ambient temperature. Compartment inside dimensions of 13½" high, 8½" wide and 6" deep provide storage capacity for twelve 12 ounce cans or one plastic one gallon jug. With a one gallon plastic jug in place there is limited additional room for storing food.

The cooling compartment door is of unique design. It has a recessed handle and travels vertically in guides. There are no latches or hinges to maintain and no aisle space is needed to gain access to cooler contents. Access is gained gy gripping the door handle and moving out and up, then lowering vertically in guides, located in the frame. Whenever the door reaches end of guides, vertical movement ceases and entry to the entire compartment is achieved. To close, the door is moved upward to the top of the guides, then moved in and down slightly to seal. Weight of the door causes gravity sealing, with vibration tending to create a tighter seal. Automatic temperacontrol is provided through use of a semiconductive device having no moving parts. Also, an adjustment feature allows for setting to desired compartment temperature above freezing. The cooling compartment is securely mounted to a very ruggedly constructed metal frame. Both sides and rear compartment walls fit against heat sinks, which dissipate heat absorbed at the thermoelectric module cold junctions. The heat sink fins are covered with vented metal side and rear panels attached to the frame. Also, the metal top cover has vented areas along three outer edges relative to a corresponding heat sink enhancing the unit's heat dissipating capability. An external fuse holder cap is accessible for fuse replacement.

The thermoelectric process is one of the latest advances in the field of refrigeration. It is a means of removing heat from one area and depositing it in another area using electrical energy as a carrier instead of a refrigerant. Its major growth has been in the area of portable refrigerators and luxury type stationary domestic refrigerators, water coolers, and in the cooling of scientific apparatus used in space exploration.

In the thermoelectric process cooling is produced without the use of conventional equipment necessary in a vapor system (compressor, evaporator, condenser, and refrigerant, etc.). Outstanding features of the thermoelectric units are: it has no moving parts, is silent, compact and requires little service.

Since electric current is the only requirement and there are no refrigerant lines, cooling in several different locations can be provided by one source of power through the use of several thermoelectric modules. This unit can operate in any position.

The overall size occupied by the refrigeration unit is far less than that which is required for conventional refrigerators of equal cooling capacity.

Because electric flow can be precisely controlled with solid state controls, thermoelectric refrigeration provides extremely accurate and narrow tolerance temperatures.

The discovery of the basic principle of thermoelectric refrigeration can be traced to a German physicist, Thomas J. Seebeck. In 1820 Seebeck made the discovery that if a closed circuit was made through two different materials in contact with each other, an electrical current flowed in the circuit when heat was applied at one of the junctions. This should have suggested to Seebeck that a current was flowing through the entire circuit. However, he did not so interpret it, and his discovery remained dormant for many years.

In 1834, Jean Peltier discovered that when a direct current passed through a junction of dissimilar metals, the junction became either hot or cold. Peltier, like Seebeck, failed to see the significance of this in relationship to thermoelectric cooling.

In 1838 Emil Lenz clearly showed the importance of both Peltier's and Seebeck's discovery by placing a drop of water on a junction of two dissimilar metals and passed direct current through the circuit. When the current flowed in one direction, the water froze. When he reversed the directional flow of electricity through the metals, the ice melted. However, Lenz also failed to realize the significance of this and the knowledge remained dormant for over 100 years, mainly due to the unavailability of materials (semiconductors), which could produce wide temperature differences.

It was not until the early 1930's that development of semiconductors made the application of Seebeck's and Peltier's discovery applicable to spot cooling. In the 30s and 40s, thermoelectric progress was limited mostly to scientific laboratories. In the early 60s many companies began an intense drive to manufacture refrigeration equipment based on the thermoelectric principle. From the 60s on, we have seen the production of full-size refrigerators, water coolers, portable coolers, and spot appliance coolers for both domestic and industrial use.

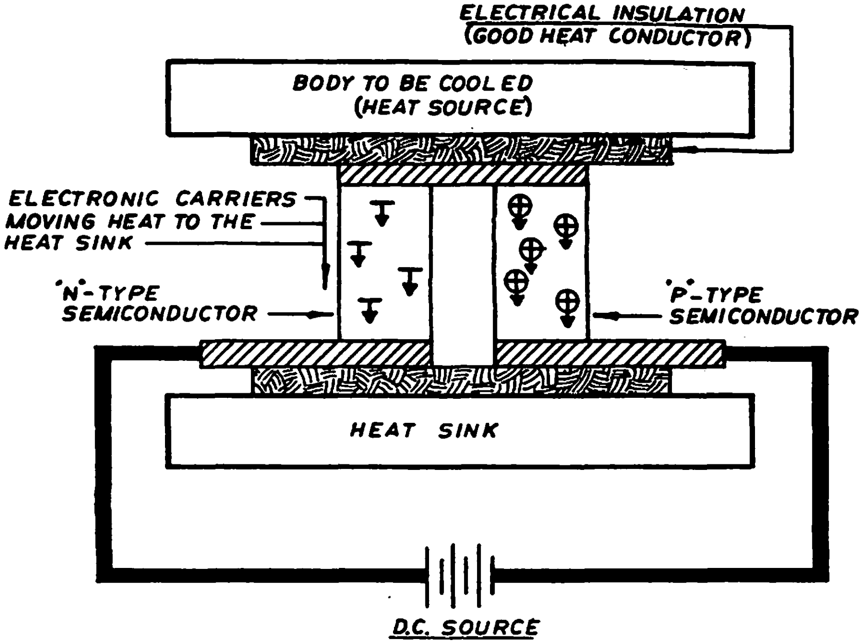
It should be noted that the direction of DC current flow determines which junction will be warmed. Reversing the flow of current will reverse the cold and warm junctions.

The basic principles just outlined are utilized to their fullest extent in the design of a thermoelectric cooling mechanism. As was mentioned with the Peltier effect, when a current is passed through two dissimilar semiconductors (P and N), heat is liberated at one junction (hot) and heat is absorbed at the other junction (cold).

Fig. 1

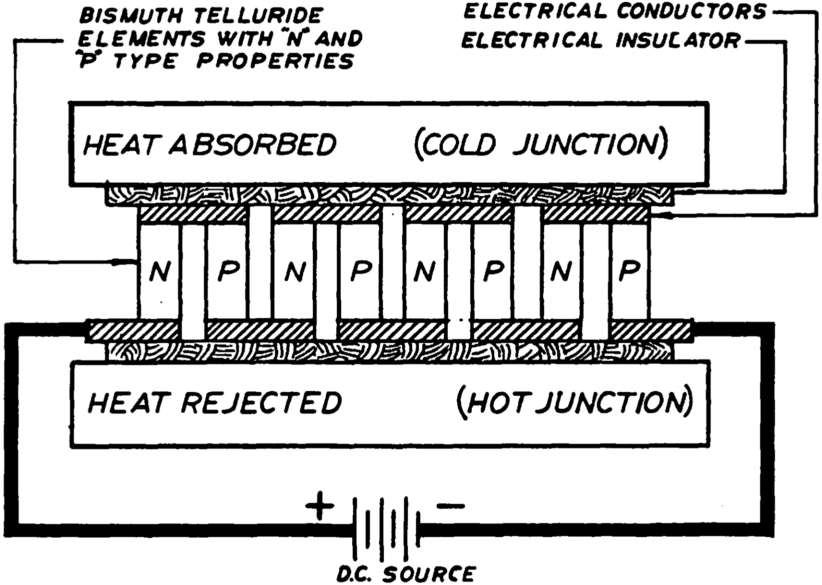
Referring to Figure No. 1, as electrons pass from P to N they absorb energy, making one junc-

Fig. 1



CROSS SECTION OF TYPICAL THERMOELECTRIC COOLER

Thermoelectric cooling couples (Fig. 1) are made from two elements of semiconductor, primarily Bismuth Telluride, heavily doped to create either an excess (N Type) or deficiency (P Type) of electrons. Heat absorbed at the cold junction is pumped to the hot junction at a rate proportional to carrier current passing through the circuit and the number of couples.



TYPICAL MODULE ASSEMBLY — ELEMENTS ELECTRICALLY IN SERIES AND THERMALLY IN PARALLEL

In practical use couples are combined in a module (Fig. 2) where they are connected in series electrically and parallel thermally. Normally a module is the smallest component commercially available.

tion cold. When electrons pass from P to N, the energy which has been absorbed at the cold plate is released at the opposite junction, making this surface hot. This is an example of a single thermoelectric couple which acting alone has very little cooling capacity.

Fig. 2

In order to achieve a larger cooling capacity it is necessary to connect a number of thermoelectric couples in series, as illustrated in Figure No. 2. To accomplish this, thermoelements are imbedded in the walls of a unit between an insulating material and the cold plate which are separated from the thermoelectric couples by the use of electrical insulation. By reversing the flow of current, the cold and hot junctions will be reversed, and heat will be produced in the cavity which was formerly cooled. This reversal of electron flow enables the unit to become a heat pump.

It is very important to remember that the letters P and N as used in thermoelectric applications and as used here, DO NOT refer to electrical current polarity (+) and negative (—), but rather refer to the characteristics of the semiconductor materials, which are also designated as positive or negative depending on how the semiconductor electrons behave under the influence of current flow.

The temperature difference, which is obtained at the various junctions, is dependent on properties of the materials used, number of thermocouples used, and the rate of current flow. In order to obtain the best temperature difference between the hot and cold junctions, the materials must have a low thermal conductivity and high electrical conductivity. One semiconductor metal that meets these requirements is bismuth-telluride.

As the characteristics of the material are known, it is possible to determine the temperature difference between the junctions. Because of the greater quantity of heat collected at the hot junction, it is often necessary to provide a series of fins, a fan, or water cooling to the hot side to remove absorbed heat. The absorption of heat at the hot junction will help produce a lower temperature at the cold junction.

The thermoelectric refrigeration system may be compared to a vapor compression system. The main objective in both vapor and thermoelectric cooling is to provide a means of obtaining a change in energy level at the hot and cold junctions of the system. With a thermoelectric system this is accomplished through the use of two different materials and a direct current. If the P and N materials were the same, the energy level would be the same and there would be no energy change. There would, therefore, be no cooling or heating. In both systems, heat is absorbed at one place and released at another. With the vapor system the refrigerant control valve alters the pressure and enthalpy of the refrigerant allowing it to absorb heat from the evaporator (cold junction) and eject it through the condenser (hot junction). Without the use of the refrigerant control valve it would remain at a constant pressure throughout the system, and no heat pumping action would occur.

Ordinary metals that are good conductors of electricity are poor insulators. The P and N-type materials used in thermoelectric refrigeration systems are known as semiconductors. These materials have the qualities of both ordinary metals and insulators. The ideal semiconductor is a material that is a poor conductor of heat because heat is absorbed at one end and rejected at the other end. However, the semiconductor must also be a good conductor of electricity in order to minimize the voltage drop. It must also have a high coefficient of voltage-temperature relationship.

A favorable material for semiconductors is bismuth-telluride. This bismuth-telluride N-type material is treated ("doped") in such a manner that it will have an excess of electrons. The P-type semiconductor is treated ("doped") to have a structure that is not completely filled with electrons. The two materials are connected by a good electrically conductive material such as copper. The P and N material contains a certain distribution of electrons, which are free to move in either direction. Movement of the electrons is dependent upon either temperature or electrical potential difference.

The cooling effect of a semiconductor comes from energy absorption by the electrons as they flow from the P material into the N material. If the electron flow is reversed, the electrons release heat as they flow from the N material into the P material. An example of this is to heat a piece of metal at one end and notice the increase in temperature at the opposite end. This is due to the increase of kinetic energy of the electrons at the hot end and a consequent flow of electrons toward the cold end. The movement of the electrons also transports heat toward the cold end. Because heat laden electrons also carry electrical charge, the flow of heat will be accompanied by a flow of electrons. This is the basis of the operation in a thermoelectric unit. The electron flow transports both heat and electricity, it is therefore possible to transport heat directly through electric current.

Due to the assembly of electrons in the structure of the molecule, positive (P) and negative (N), current passing through the P junction of the thermoelectric module into the N material requires energy. The electrons, therefore, pick up this energy which leaves the interface material cooler (removes heat). When this occurs in a thermoelectric module the cold side removes heat from the section to be cooled and releases its heat in the hot side of the module.

When a battery or electrical current DC is applied with the negative terminal attached to the P-type material (lack of electrons), the copper plate will become cold and absorb heat from the surrounding area. Electron flow is from the battery through the P material where there is a lack of electrons and will pick up heat from the cold surface and reject this heat at the opposite plates.

In conclusion, the railroad industry must have a water cooling or refrigeration system geared to the needs of today and tomorrow's train crews. This must take into consideration pending state and federal legislation that could prohibit many present water dispensing and cooling methods in wide use on locomotives. Also, just over the horizon is possible standard train operation without utilizing a caboose and this would call for increased system storage capacity. The device must be technologically advanced enough to be able to survive in the tough locomotive cab environment and simplistic enough to be maintained in proper operating condition by a limited number of trained maintenance personnel. The future holds many challenges but few promising directions to pursue. Maybe the thermoelectric principle holds the answer to this very complexing problem and this direction must be pursued.

DIESEL ELECTRICAL MAINTENANCE

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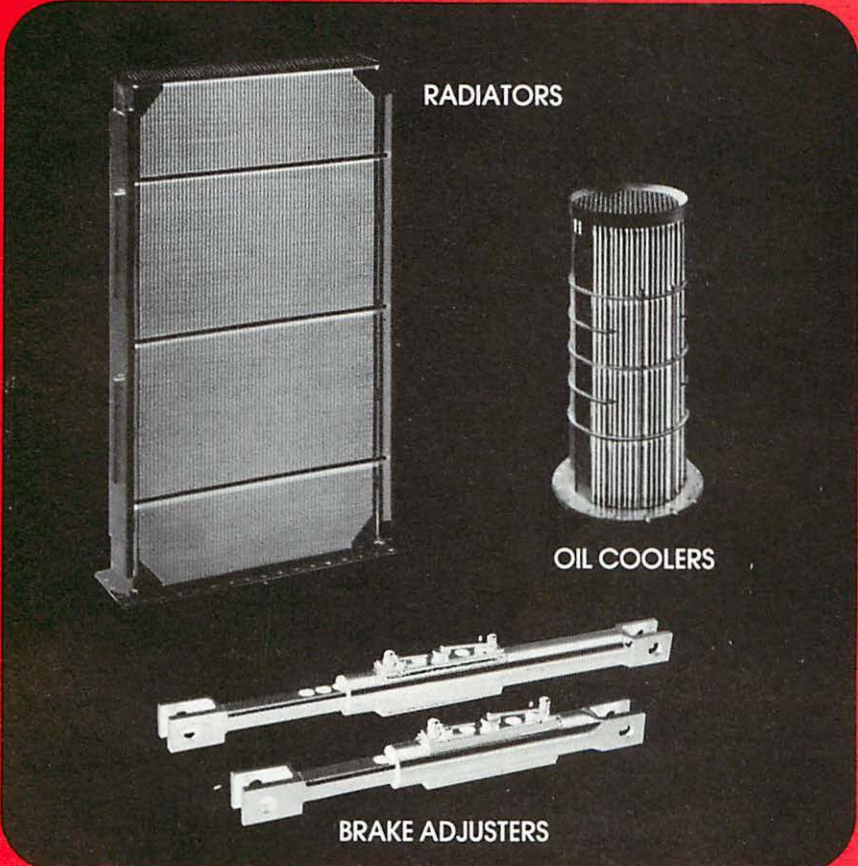

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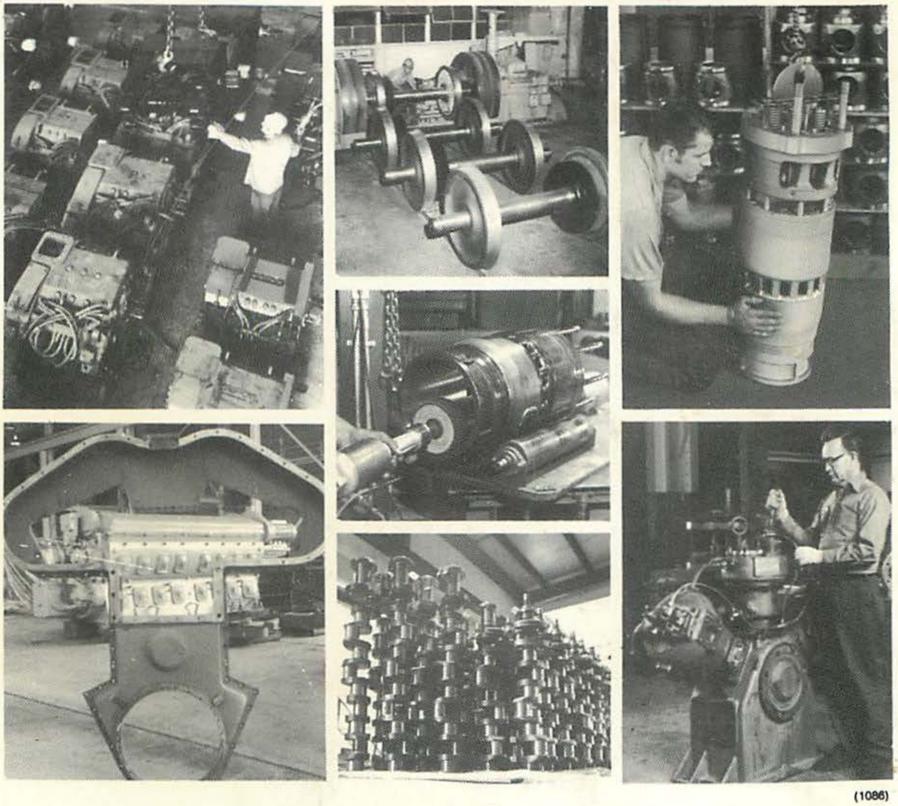

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