LMOA

1983 ANNUAL PROCEEDINGS — 1984 PRE-CONVENTION REPORT

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SEPTEMBER 24, 25, 26, 1984

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Official Discussion Record of 45th Annual Meeting

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MONDAY MORNING SESSION
September 19, 1983

FRANK D. BRUNER
PRESIDENT
Asst. Chief Mechanical Officer - R. & D.
(Retired)
Union Pacific Railroad
Omaha, NB

MONDAY MORNING SESSION
September 19, 1983

The 1983 Annual Meeting of the Locomotive Maintenance Officers Association, held at the Conrad Hilton Hotel, Chicago, Illinois, on September 19-20-21, 1983, convened at 9:05 a.m., Mr. W. E. Caldwell, President of the Car Department Officers Association, presiding.

MR. CALDWELL: Good morning, ladies and gentlemen. I am Ed Caldwell, Superintendent, Car Department, Southern Railway, and this year's President of the Car Department Officers Association.

On behalf of the Car Department Officers Association, the Air Brake Association, the Locomotive Maintenance Officers Association, the Railway Fuel and Operating Officers Association, the Railway Supply Association and the Executive Committees and their officers, it is a pleasure to welcome you to Chicago and to this 75th Annual Technical Conference, which I declare now to be in session.

Continuing a long history and tradition of this conference, of putting first things first, will you all please rise for the invocation, to be given by Dr. William D. White, senior minister, Chicago Temple, First United Methodist Church, Chicago. Dr. White.

REVEREND WILLIAM D. WHITE: I wonder if I may bring a greeting to you first. I am not officially supposed to do it, but I just got back from China and I notice you have some people from China on the program. I want to tell you the Chinese railroads start on time, end on time, they are clean, not the fastest in the world, but consider this:

If you had one billion people within the borders of the United States and no one company owned a private car, what a responsibility you would have! So, I want to tell you there are other railroad persons around the world really working at it. It is a wonderful country to visit, and I bring you their greetings.

Shall we pray.

O God, we are grateful for the ability and privilege of connecting families and tying industries together and crossing all borders of this great nation. We ask for a wisdom greater than our own. Invade our minds and hearts as we gather together in these days, that all of our meetings this week may be cordial and candid and creative. Bless the leadership of all the organizations represented here. Give them strength and foresight. Bless all the families represented in this room, and grant to all of us a safe return home. These things we ask in the Name of Jesus Christ our Lord. Amen.

MR. CALDWELL: Thank you, Dr. White, for your words of inspiration and guidance, which we can all apply both for a successful conference here and to our individual jobs and lives when we return home from this convention.

It is a privilege to again open this conference with a joint meeting. Our organizations share the responsibility and goals of operating trains safely, efficiently and profitably, and this joint meeting recognizes that such a Herculean task requires the skills, dedication and, most of all, the cooperation of each of us.

Before our keynote address this morning I would like to introduce the persons here at the speaker's table and ask that each rise as he is introduced, and remain standing. Please hold your applause until all have been introduced.

Seated on my immediate left, Mr. Harold H. Hall, President and Chief Operating Officer, Norfolk Southern Corporation, and this morning's keynote speaker.

Next on my left, L. Dale Gaeth, President of the Railway Supply Association.

Next, Mr. E. F. Wilcox, this year's President of the Air Brake Association.

Mr. F. D. Bruner, President of the Locomotive Maintenance Officers Association.

To my right, Dr. White, from whom we just heard.

Mr. J. R. Mecaskey, President of the Railway Fuel and Operating Officers Association.

Mr. William J. Burrows, Executive Secretary, Railway Supply Association.

Mr. W. H. Cyr, Chairman of the Coordinated Associations.
[Applause]

I believe our keynote speaker this morning will be one you can all relate to, because not only is he president of one of the giants in the railway industry but he is himself a man experienced in the operating department of the railroads, and he understands and appreciates the challenges and responsibilities facing those of us in these coordinated groups, and particularly in the mechanical groups.

Mr. Harold H. Hall, President and Chief Operating Officer of the Norfolk Southern Corporation, was born in Andrews, North Carolina on April 30, 1926, the son of Dell Chandler Hall and Myrtle Roland Hall, and except for approximately three years with the U. S. Navy during World War II he worked continuously for the Southern Railway after joining the company in 1943 as an agent telegrapher at Andrews.

Rising steadily through Southern's ranks of the Operating Department, he touched all the bases —train dispatcher, trainmaster, division superintendent, general manager of both lines East and lines West, Vice President for Transportation, Senior Vice President Operations, Executive Vice President Operations, President, and finally President and Chief Executive Officer. He was made President in 1979, and a year later was given the added title of Chief Executive Officer, a post he held until becoming Norfolk Southern's first President and Chief Operating Officer when that corporation was formed on June 1, 1982 by the merger of Southern Railway and Norfolk and Western.

Mr. Hall is a Director of the Norfolk Southern Corporation and of several other organizations, including Riggs National Corporation, Penn Virginia Corporation, Richmond, Fredericksburg and Potomac Railroad Company, and Florida East Coast Railway Company.

He has completed special management courses at the Transportation Graduate School, American University, Transportation Institute, Northwestern University, and the Advanced Management Program, Harvard University. He is married to the former Mary Elizabeth Abernathy, of Andrews, and they have two children.

It is with great pleasure that I welcome this outstanding leader of the rail industry as our keynote speaker. Mr. Hall. [Applause]

MR. H. H. HALL: Thank you, Ed. Ladies and gentlemen, it is particularly good to see ladies present in a railroad group. Their beauty and vivaciousness always adds a lot to any group of railroaders. I think all of you will agree with that.

I am not sure I can live up to the introduction that Ed just gave, but I am very flattered to be invited to give you the keynote address for your meetings during the next three days. It is flattering to be asked to set the keynote for a gathering as important as this. Certainly it is a challenge to seek out the common denominator to help develop guidelines for a group so large and so diverse.

However, a look at the array of complex and technical subjects you will be dealing with during these few days does produce the germ of an idea. Everything that concerns you here represents something basic to our business, and in coping with these basics you are setting down the foundations for the important role railroads will continue to play in 1984 and the years beyond.

If experience is any guide—and if our economic forecasters are not too wide of the mark—1984 should see railroads supporting and benefiting from a recovering economy.

Surprisingly, our railroad industry maintained its level of business activity and revenues longer than almost any other industry when the economy took a nosedive two years ago. Unfortunately, there is another side to the coin. We are also having a harder struggle than most on the way up. But the fact that we could hold the line as well as we did on the downturn in economic activity, and weather a pretty deep recession as well as we have, says a lot about the basic strength of our industry now.

There was a time—and not too long ago—when some railroads could not have survived the kind of economic weather we have had in the last year or so. But the strengthening effect of the rail mergers and contributions we have seen in recent years is helping us be better competitors. We can deliver single system service over longer distances and serve a wider geographical array of customers.

And the new marketing freedoms available to us as a result of the degree of deregulation accomplished under the Staggers Act let us put our competitiveness to good use.

Railroads can and do react more quickly to changes in the transportation market place. Nowhere is this having greater effect than in the field of intermodal, where pricing freedom is spurring the growth of our piggyback business. Beyond that, the indications are clear that the regulatory barriers to intermodal ownership and total transportation are coming down.

HAROLD H. HALL
President and Chief Operating Officer
Norfolk Southern Corpration

Wider use of contracts is giving us the opportunity to firm up price and service relationships with customers over long enough periods of time to make service and equipment commitments practical for us. Since these contracts have proved useful to shipper and carrier, we can expect to see more of them.

For a number of reasons, we can look to railroads to provide a solid base for what we hope and expect will be an economy steadily recovering strength in the next year or two. Already we are beginning to see improvement in the merchandise transportation business, at least in some parts of it. This has been true on Norfolk Southern's railroads, and I believe has been the case on others as well.

Revenues on paper, chemicals, transportation equipment and intermodal have been heading upward. Although export coal traffic, which is an important revenue producer for my railroads, is well below the record levels of a year or so ago, coal for utilities and steel production is showing some strength for us. And on the subject of coal, I am delighted to see a couple of railroads outbid a fledgling slurry pipeline for a lucrative utility coal hauling contract.

But if railroads have the potential for benefiting from a recovering economy, it is strictly a potential. How well that potential is realized—how good a base railroads prove to be for the recovery we look for—depends to a great extent on the people in this room.

That's the challenge I would like to put to you today.

You are responsible for some of the basics in our business—the track on which we operate, the locomotives and cars we use, and the people who maintain them. The line-up at programs I have seen for your meetings here makes it plain that you are giving intense study to the technology of our business.

That is all to the good. Railroads are far more affected by, and responsive to, modern technology than most people realize. The challenge we face is to use our research and technology to stay lean and efficient, to continue to do a better job with fewer people.

If there is any advantage to be had from undergoing periods of economic stress, it is the enforced discipline of making the most of every resource. Under the pressure of reduced business and revenues we soon learn to readjust our sights from what it would be useful to have to what we absolutely have to have, and we learn to use those basic essentials wisely.

In good times and bad, people are the most valuable and expensive resource we have. We can never afford to waste or misuse their efforts — or to have more people than we need to get our job done effectively.

During the recession we have had to do some drastic streamlining of our work forces. We did this with regret because we never like to let our good people go. But the experience held a valuable lesson for us. Technology had helped make us more efficient, our people more productive. Still there was more progress to be achieved in this direction and, under the pressure of events, we did it. Now we can't let a business recovery tempt us to relax, because the need for efficiency and productivity is just as real and just as compelling as it was a year ago. A recovering economy won't mean a lessening of competition—just more business to compete for. There will be a lot of other hungry carriers out there fighting for business—trucks and water carriers and pipelines, contract carriers and private carriers.

Nor is ours the only competitiveness at stake. Our nation is locked in a struggle for markets with other nations that have manufactured products to sell.

America was once the industrial focus of most of the world, the leader in manufacturing technology, whose expertise in mass production others sought to copy. Now we face growing competition from other countries in the world's economic market place. Often this competition comes from countries whose manufacturing plants are more modern than our own because they have been rebuilt with American capital.

I do not mean to imply that railroads can somehow upgrade the production facilities of American industry. Certainly we can do nothing to slow or reverse the trend away from heavy manufacturing to lighter industry, research and service businesses; but we can make our part of the mass production and distribution system as efficient as possible.

Much depends on the ability of the American economy to sustain the recovery we see beginning. That ability will be affected to a large degree by the efficiency and productivity of the transportation system on which industrial production depends. And for a large share of the freight that moves in this country, transportation means railroads.

Basic heavy industry — steel, chemicals, plastics, auto and equipment maufacturing — will remain to undergird all else in the economic structure. Railroads must continue to serve that heavy industry by transporting raw materials and finished products.

Food production and distribution will continue to rely on rail transportation — from carloads of lime and fertilizer for the fields and grain for the feed lots to refrigerated trailer loads of meat for the supermarket.

Railroads will still be moving mountains of coal for energy generation, steel production and industrial heating—here and abroad.

What we do is basic to America's business, just as what you do is basic to our railroad business. But that doesn't guarantee anything to either of us, unless we work at it. Basics have a way of changing, as we have all had reason to learn.

Railroads are looking in new directions—and so are railroad customers.

More and more, when we talk about railroads we are really talking about railroad-based transportation systems whose capabilities extend far beyond the reach of steel rails. Rail-highway intermodal traffic continues to be the fastest growing part of our business. Now the Interstate Commerce Commission seems to be opening the way to railroad acquisition of trucking companies. One railroad, Norfolk Southern, is also looking at the start-up next year of a rail-barge-ship combination for topping-off large capacity coal ships for overseas movement.

Some shippers who once looked to railroads or barge lines for the transport of coal are now seriously involved in the effort to start up coal slurry pipelines for the long-distance transport of coal to power plants or port facilities. Proponents of pipelines are closer than they have ever been to winning Congressional action to allow them the right of eminent domain they feel they must have to make pipeline construction feasible.

I didn't bring that up in order to issue a warning about the perils of coal slurry pipelines. Most of you know and share my feelings on that issue. I simply want to make the point that the resurgence of the coal slurry pipeline proposals, after almost a generation of lying fallow, is one more bit of evidence that we are dealing with a period of constant change. Deregulation has changed our relationships with one another in the railroad business. It has exposed us to antitrust penalties if we do not change some practices that had been standard among railroads in the past. It continues to open to us new opportunities to respond quickly to market changes and to diversify our transportation services to customers.

Change is always unsettling, but it can often be turned to our advantage if we are aggressive and efficient in meeting it. That's our key to making railroads the solid base for a recovering economy — as I believe we are determined to do.

To sum up very briefly, here is how I see our situation now:

Deregulation has given us a number of new tools to work with.

Economic adversity has compelled us to sharpen them to a keen edge and use them with greater skill.

The combination should certainly work to the benefit of our customers and our railroads in the better times we believe are ahead.

And we're counting on you to help make that happen. [Applause]

MR. CALDWELL: Thank you, Mr. Hall, for your words of encouragement and for leading us with your keynote speech and setting the tone for what we hope will be a most successful technical conference and one which will help the railroads shape their destiny and their operating practices in the future.

I want to thank you all for being here for the opening ceremonies and keynote address. We will now adjourn to our individual sessions. Thank you.

[Recess.]

MONDAY MORNING SESSION
September 19, 1983

REPORT OF THE COMMITTEE ON NEW DEVELOPMENTS

A. A. CHACON, Chairman
General Mechanical Engineer
Union Pacific Railroad
Omaha, NE

B. A. CUMBEA
5th VICE PRESIDENT
Manager Loco. Maint.-Engineering
Chessie System
Huntington, WV

[Mr. Frank D. Bruner, President of the Locomotive Maintenance Officers Association, assumed the Chair.]

PRESIDENT BRUNER: Welcome to the LMOA sessions, gentlemen. It is certainly my pleasure as President to open this particular meeting, in view of what we were faced with last year. It didn't start off very well. I did manage to get here on the second day, and there are more members here now than then. The thing that was amazing was all the suppliers here last year. We certainly appreciated their support.

I don't have any special announcements before we begin. We are looking forward to having a good meeting.

I am going to call first on Mr. Bud Cumbea, our 5th Vice President, to introduce the Vice Chairman of the New Developments Committee. Their Chairman, Tony Chacon, was called back to his railroad for a meeting, and I understand he will probably get back here before we conclude our meeting.

New developments are dear to my heart. I have been in that area for a number of years. On May 1

I retired as Assistant Chief Mechanical Officer, Research and Development. That has been dear to my heart also, and I am sure we will all appreciate the Committee's fine presentation this morning. Mr. Cumbea, will you please come to the podium.

MR. B. A. CUMBEA [Manager Locomotive Maintenance-Engineering, Chessie System, Huntington, West Virginia]: Thank you, Frank. It certainly is a pleasure, after the disaster of last year, to see so many railroaders here this morning and to welcome all the supply men who supported us so well last year.

As Frank indicated, Tony Chacon was unfortunately called back to Omaha for the day. He is very ably represented by the Vice Chairman of the New Developments Committee, Maurice B. Campbell, Shop Superintendent, Chicago & North Western Transportation Company, Oelwein, Iowa.

MR. M. B. CAMPBELL [Shop Superintendent, Chicago & North Western Transportation Company, Oelwein, Iowa]: Good morning, gentlemen. It is good to be first on the program because I am sure all of you are wide awake and we can have your full attention.

We feel we have an outstanding paper to present this year about a host of subjects that are near and dear to our hearts, subjects that are pertinent to the railroad industry now and in the future. I feel that all of us will enjoy the papers and that you will have something to take home with you when you leave here, and something to think about and talk about when you get back home.

Before I introduce the members of our Committee I want to express our thanks to the Chicago Railway Diesel Club for allowing us to present our pre-convention paper last spring, and to thank them for the very fine reception we had and the consideration from their members. Again, we appreciate it very much.

[Mr. Campbell introduced the Committee. Mr. M. M. Staroschak, Electrical Design Engineer, Southern Pacific Transportation Company, San Francisco, California, summarized Part I of the paper.

MR. STAROSCHAK: We will spend a few minutes for a question-and-answer period. Does anyone have a question? If there are no questions, thank you very much.

[Mr. V. G. Lord, Shop Manager, Conrail, Selkirk, New York, summarized Part II.]

MR. LORD: Are there any questions? [No]

[Mr. T. L. Scott, Assistant Shop Manager, Southern Railway Company, Chattanooga, Tennessee, summarized Part III.]

MR. SCOTT: Any questions? [No]

[Mr. W. M. Reed, Manager Facility Planning, Burlington Northern Railroad Company, St. Paul, Minnesota, summarized Part IV.]

MR. REED: Are there any questions? [No]

VOICE: If you don't mind, I would like to go back one speaker and ask a question about fuel gauges. Has any thought been given to incorporating fuel gauging with automatic shutoff when filling up tanks?

MR. M. B. CAMPBELL [Shop Superintendent, Chicago & North Western Transportation Company, Oelwein, Iowa]: Yes, there has, and that would be one of the primary functions of the new type gauges. They will have that capacity.

VOICE: In other words, the Committee is definitely interested in that sort of arrangement?

MR. CAMPBELL: Yes.

[Mr .W. A. Coles, Facility Planning Engineer, Missouri Pacific Railroad Company, St. Louis, Missouri, summarized Part V.]

MR. COLES: Are there any questions?

VOICE: What will be your minimum capacity as far as labor or people are concerned, and what do you expect your output to be? How many heavy repairs can you do in a day? What is the capacity for your output?

MR. M. A. COLES [Facility Planning Engineer, Missouri Pacific Railroad Company, St. Louis, Missouri]: As far as the number of people are concerned, if everything is filled up to capacity we will have locker space for nearly 900 people. Of course we will not have that number for a good long time. When we started to build the shop we were told to build it to be sufficient for the next fifty years. Nobody knows what is going to happen in the next fifty years, but we put that kind of capacity into it.

The shop is designed primarily to operate as a heavy first shift operation with a fill-in second. To try to run a shop with three shifts a day could be a problem. At that kind of work level, with one heavy shift and a fill-in second, we feel we can output a heavy locomotive overhaul, one per day, and if we are in a remanufacture program we can output as many as three a week.

We have locomotive space in the building for nearly 34 locomotives, and they are spaced quite a distance apart. Again, the output of the shop will be based on how big a program we are running, what type of program we are running, and how much money is made available. We did put that kind of capacity in the shop.

MR. CAMPBELL: If there are other questions about any of the topics covered, we will be happy to address them now.

MR. T. L. WESTERFIELD [Senior Electrical Engineer, Chicago and North Western Transportation Company, Chicago, Illinois]: Several sections of your paper described any number of different electronic devices that are or possibly could be added to a locomotive. Has any work been done by the builders toward defining the electrical environment for the electronic equipment that has to live onboard the locomotive as a first step, and secondly toward publishing the specifications of that environment and perhaps in the future controlling the environment?

The point I am getting at is that not only does the locomotive builder put large amounts of electronic equipment on the locomotive, but after the railroads receive it we have radio communication equipment to put on, and we have warning beacon lights to put on, recording equipment to put on, cab signal equipment to put on, and all this equipment is going to affect the electrical and electromagnetic environment on the locomotive. It seems to me the whole thing is beginning to be a patchwork and is getting out of hand, and none of these things will be able to work with one another because they will cause interference.

MR. CAMPBELL: That is a very good question, Tom. I don't know if I have a very good answer.

MR. D. W. CHIRIKOS [Manager Technical Services, Electro-Motive Division, LaGrange, Illinois]: We have defined the specifications for the particular components that are used in our modules or other control system hardware. How you would relate those design specifications for the add-on I am not sure, but we do have some very stringent specifications for the various solid state devices that are required to make the control system operate.

As far as putting them in an environment of their own, are you talking about some sort of constant temperature and humidity system? Is that what you are referring to?

MR. WESTERFIELD: My concern was more with the electromagnetic compatibility. We have been through the experience of discovering that our beacon lights were causing interference with our communication radios, for example. There is nothing to say that a beacon light couldn't cause interference to the control system, or the radio might cause interference into the control system.

Is there any trend toward trying to make the electromagnetic specification for the Electro-Motive as a system public so that all the component sources that have to be put together can work together?

MR. CHIRIKOS: I am not aware of anything at this time in that regard, Tom. Even if we did arrive at a spec I think you would have to try the various components you would add on to see what they would do. I don't know if one spec or set of specs would totally get that job done. I am sure there would have to be some onboard testing performed.

MR. WAYNE EWING [Altoona Gear Company, Altoona, Pennsylvania]: That first section got away from me a little too quickly. This has to do with the microprocessing section.

It is hoped that some railroads will make use of the microprocessor technique to monitor adhesion to the rail. Most railroads have been convinced that good profiles on axle gears save traction motors. How can we monitor each wheel set on a given locomotive, equip it with gears ranging from new to .010, .020 and .030 out of profile? Our company would be anxious to furnish gears in proper conditions for one or more railroads at no charge, and pay some money also to develop these conclusions for everyone's benefit.

I have two questions. First, are microprocessors available for use on existing locomotives, or must we wait for statistics from new locomotives?

Second, which railroad or railroads can or intend to investigate in this manner? We very much want to work with them. That is not necessarily a commercial.

MR. M. M. STAROSCHAK [Electrical Design Engineer, Southern Pacific Transportation Company, San Francisco, California]: We at the Southern Pacific are engaged in an active program working with an outside automation company to develop a retrofit package for the ST45 Dash 2 locomotive, wherein we will replace large sections of relays and modules with a microprocessor-controlled package. We envision conservatively about a 10% reduction in the capital costs for components.

We have a heavy overhaul program that we call a GRIP, where we pretty much rebuild the whole locomotive, so we envision both capital savings and some pretty significant operating advantages particularly in the troubleshooting and identification of programs.

I guess the answer to your question, as far as retrofit packages are concerned, is that you will have to wait until what we are doing at Southern Pacific—and we are the only railroad I know of that is doing anything. I don't believe the major manufacturers are working on a retrofit package. They are pretty much spending most of their efforts in developing their prototypes in developmental models.

Does that answer your question? Thank you.

MR. CAMPBELL: Any other questions? If not, Mr. Goehring will summarize the paper.

MR. D. G. GOEHRING [Manager Maintenance Planning, National Railroad Passenger Corporation, Washington, D. C.]: The New Developments Committee has fulfilled its mission of bringing to this assemblage, and to those who read their paper, a report on some

D. G. GOEHRING
REGIONAL EXECUTIVE
Manager Maintenance Planning
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Washington, DC

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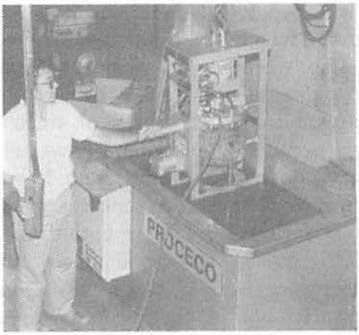

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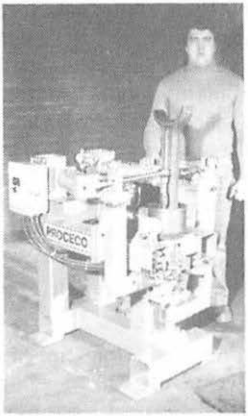

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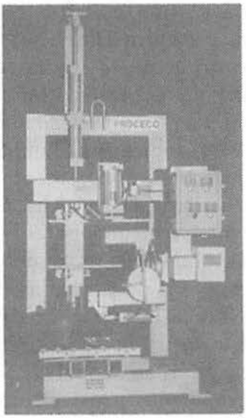

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of the railroad industry's latest achievements and success in improving locomotive maintenance techniques and ways to reduce operating costs.

As predicted in past years, onboard electronic surveillance of vital locomotive functions is a goal of the locomotive industry. The excellent report on microprocessor systems has not only brought us information on the present state of the art, but describes how solid state devices are constructed, how they work, their present successful applications, and their potential. It has exposed the good news that microprocessor systems are becoming reliable in the locomotive environment and more affordable.

An accurate locomotive fuel gauge is not yet here, but more has been done to solve this problem in the past two years than during the previous two decades. As a start, the gauge manufacturers have improved the material in the working parts of the gauge. Why has it taken so long? A manometer using a separate, freezeproof indicating liquid is another simple improvement to a very practical gauge. The ultimate fuel gauge will undoubtedly use a solid state device to monitor the fuel level, visually display it, and initiate a printout when desired. There is a need for all of these gauges in the railroad industry, and these developments are welcome.

If you have ever ridden the head end of a train at 100 mph, you can feel the power of the wind pushing against you. At speeds above 50 mph flat and concave surfaces begin to add measurably to the horsepower and fuel needed to operate a train. EMD's wind tunnel testing has proved this, and for the first time locomotive manufacturers are paying attention to car body styling and reducing wind friction as a simple and practical way to improve fuel efficiency.

What happens when mechanical officers get involved in locomotive design? Ask Bombardier and they will be happy to tell you. Mr. Draper of the Canadian National had some ideas and Bombardier listened. The result is an innovative locomotive design that can solve the operating challenges of many American railroads. The locomotive is designed for mechanical accessibility, crew comfort, ease of operation, maximum fuel efficiency and safety.

There have been many new locomotive shops built in the past twenty-five years. They were built for periodic maintenance, running repair and locomotive overhaul. Not until Missouri Pacific decided to build a new shop at Little Rock did a railroad undertake the design and construction of a new facility capable of locomotive and component rebuild, heavy repair, fire and accident damage.

The planning and financial analysis that went into the development of this shop is an example of some of the best industrial engineering ever carried out on an American railroad. The result is a self-sufficient shop that encompasses modern production-line work flow with the flexibility for spot, heavy repairs that will achieve absolute minimum turnaround time for scheduled and unscheduled work. The unique and thorough approach carried out by the Missouri Pacific can be a guide to any who would undertake a facility planning project, regardless of its size.

This paper is about new developments and about their impact on railroad operating efficiency, and it is a good one.

Now I will turn the meeting back to Bud Cumbea.

MR. CUMBEA: Thank you, Dave. I certainly would like to express my sincere appreciation to Tony Chacon for the leadership he showed in developing this paper today, and to Maurice Campbell for so ably filling in in Tony's absence.

I believe Frank has some closing announcements.

PRESIDENT BRUNER: We thank all of you. It has been a great panel, and you have all done a fine job.

I understand we have a visitor from Chile, Patricio Manzor, of the Bolivian Railway. Is he here? If so, we would like to welcome him. I am sure we have other guests here this morning, too. It is a pleasure to have you here. We can't introduce everyone, but I am sure we also have some special guests from the Department of Transportation and some other people whom we will try to introduce this afternoon.

We have had a fine session this morning. We appreciate your participation and questions. Let's give a rising vote of thanks to our panel.

[The audience arose and applauded.]

[The meeting recessed at twelve o'clock noon.]

MONDAY AFTERNOON SESSION
September 19, 1983

The meeting reconvened at 2:00 p.m., Mr. Frank D. Bruner, President, presiding.

PRESIDENT BRUNER: We will proceed with the agenda for the afternoon. The program says I am to give an address as President of the LMOA. It is my pleasure to be here to address you. After twenty years or more with the LMOA, becoming President is the icing on the cake of my 35 years with the Union Pacific, from which I officially retired as of May 1. My colleagues graciously allowed me to continue on this year and finish my year as your President.

I want to thank directly my colleagues, all the Vice Presidents, the Past Presidents, the staff, the committee chairmen and committee members, and the members of the supply group, for my success this past year, such as it was, starting out with such a rocky beginning. In fact, a year ago today, as I stood on this podium accepting the responsibility as President, I made a brief remark about being elected as president of Lebanon. We were pretty well shot up last year. The national rail crisis came along, and most of our members were involved in helping out their companies, whether it was running trains, moving traffic, or other duties during the crisis. This points out the skill and capability of mechanical officers to fill in where needed and keep things moving. We missed them last year.

I want to give special thanks to the suppliers of last year. They had commitments to be here and at a time when the economy was very depressed. It's not all that good today, however, we hope some of the positive indicators can bring about a steady recovery.

During the sessions and presentations we worked our way slowly, substituting this person for that person, and we appreciate the participants from the suppliers filling in and helping us out. The audience was very attentive. They bore with us and participated in the discussions, so it wasn't all lost. You can't expect a loss with people like those we have in the LMOA.

I also want to give special thanks to the Chicago Railroad Diesel Club, the Southwestern Railway Club, Consolidated Rail Corporation, Southern and Southwestern Railway Association, Union Pacific Railroad and the Santa Fe for hosting our six pre-convention presentations this year. Their officers and members in Huntington, Little Rock, Kansas City, Omaha and Altoona were very cordial. The only one I missed was at Altoona. I couldn't make that because of my schedule, but we were cordially

greeted and we hope we can continue with these people.

As I said, in my twenty years of LMOA work, I have seen a lot of things happen, starting out as a committeeman and committee chairman. The things that have gone on in improvements in locomotives and locomotive facilities have been tremendous. I have had the honor of being acquainted with and standing side by side and talking to some real giants in the industry, railroaders, suppliers, builders and others. It has been an inspiration to be associated with such grand people. They had visions far before their time, and some of the things you've seen here today and will see in our other presentations are extensions of those ideas and their action.

I am really optimistic that in time we will have greatly improved locomotives, improved facilities, expanded management tools, and smarter people, all of which will improve our capability to compete as we should in this great transportation industry.

Meetings like this bring qualified committee members from various railroads, and suppliers representatives together to discuss railroad problems. Before you know it, ideas and solutions are shared even though people might be on competing railroads. Problem solving must be a joint effort, with a lot of good minds and dedicated work.

It takes a lot of effort to make a good organization, and this organization has functioned as it should in order to have the image we have. I have been very proud to be President of the LMOA. It culminates a lot of year's work. The honor is worth every bit of it. I feel sometimes I didn't do my share, and that I could have done more. As I look around this room today and see the faces of friends from various associations, railroads and suppliers, our officers, I know LMOA is in good hands to carry on, grow and prosper.

I didn't come up here to sell LMOA. I don't have to do that. I just wanted to express my total commitment and friendship to you people. I don't plan to do consulting, but anything I might be able to help you with will be as near as your phone. I hope I will be able to return again next year and for many years to come.

We will continue the program. I will ask you to stand for a minute of silence in respect to our members who were deceased in the past year.

[Silent standing tribute to deceased members.]

PRESIDENT BRUNER: I would like to call on some of my assistants up here. We will have Mr. Dale Propp, Chief Mechanical Officer, Burlington Northern, serve as officer of the session. Will you come to the podium, Mr. Propp.

MR. DALE PROPP [Chief Mechanical Officer, Burlington Northern, Billings, Montana]: Thank you, Frank. We are going to miss you next year. I guess we are going to have to call you back as a consultant at times.

Before we begin the presentation by the Diesel Mechanical Maintenance Committee, we have a few housekeeping chores to take care of. This is our annual business meeting.

As 4th Vice President and General Membership Chairman, I would like to give a brief membership report. As of now the registration was 99 railroad persons registered, 90 associate members, and 32 wives. That is down a bit from other conventions, but certainly a lot better than last year.

So far, to date we have a total membership of 1,447. Of those, 985 are railroad active members, 370 are associate members, and 92 are advertisers. This represents 356 less members than we had in 1982. In 1982 our membership totaled 1,803.

Looking on the positive side of these figures, I think it behooves all of us to go home and encourage our management and subordinates who work for us to join actively in this Association. It is an excellent organization, as all of you know. We need to do as much as we can to liven it up and keep it active, and encourage membership in the future. As mergers and consolidations take place it is going to be tougher for us, but we can do it. We stand ready to do it, but we need your help. So, please go home and look for more members. LMOA is an important organization and we want to keep it active.

R. G. CLEVENGER
PAST PRESIDENT
General Electrical Foreman - Retired
Atchison, Topeka & Santa Fe Railway
Kansas City, KS

Now I would like to call on Bob Clevenger for the report of the Nominating Committee.

MR. R. G. CLEVENGER [General Electrical Foreman, Atchison, Topeka & Santa Fe, Kansas City, Kansas]: The report of the Nominating Committee is as follows:

LMOA NOMINATIONS FOR THE YEAR 1983-84

Following is the Nominating Committee's Report for the Year 1983-84.

President:
Richard R. Holmes, Director Chemical Laboratories & Environment, Union Pacific Railroad, Omaha, NE

1st Vice President:
Darrell M. Walker, Diesel Superintendent, Southern Railway, Atlanta, GA

2nd Vice President:
Dale H. Propp, Chief Mechanical Officer, Burlington Northern Railroad, Billings, MT

3rd Vice President:
B. A. Cumbea, Manager Locomotive Maintenance-Engineering, Chessie System, Huntington, WV

4th Vice President:
Elmer R. Hafling, Engineering Assistant, Atchison, Topeka & Santa Fe Railway, Topeka, KS

5th Vice President:
Donald L. Ward, Coordinator Shop Methods, Burlington Northern Railroad, Springfield, MO

6th Vice President:
Jack L. Kuhns, Manager Planning & Maintenance, Seaboard System Railroad, Jacksonville, FL

Regional Executives:

D. G. Goehring, Manager Maintenence Planning, National Railroad Passenger Corporation, Washington, DC

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

T. A. Kessenger, Senior Engineer-Facility Planning, Seaboard System Railroad, Jacksonville, FL

W. A. Brown, Superintendent Motive Power, Burlington Northern Railroad, Overland Park, KS

D. D. Hudgens, Manager Field Laboratories, Union Pacific Railroad, North Platte, NE

P. F. Hoerath, Superintendent Plant Engineering, Consolidated Rail Corp., Altoona, PA

MR. CLEVENGER [Continuing]: Are there any nominations from the floor? If not, the Secretary will cast one vote for the aforementioned slate and they will be recorded as elected.

SECRETARY JOSEPH J. T. KOERNER: I cast the unanimous vote for the nominees.

MR. PROPP: The vote is unanimous, and the slate has been accepted for next year.

As Mr. Hall told us this morning very clearly, railroads are leaner and cleaner, and more efficient and more productive. I think that is very true. No. 1, they are more profitable. Now we in the LMOA want to know whether we are profitable, so I will call on Past President Ky Pruchnicki for the financial report.

[Mr. Ky Pruchnicki, General Supervisor Locomotive Maintenance (Retired), Southern Pacific Transportation Company, San Francisco, California, read the financial report.

MR. PROPP: Thank you, Ky.

Every organization has a special person who does a lot of legwork, and certainly this organization has had that kind of person for years. As our Secretary Joe Koerner and his wife, Lou, have done so much for us, I would like everybody to give them a rousing hand of applause as Joe comes forward to give the annual report of the Secretary. [Applause]

LOCOMOTIVE MAINTENANCE OFFICERS ASSOCIATION

FINANCIAL REPORT

FOR THE YEAR ENDED DECEMBER 31, 1982

OPENING BALANCE JANUARY 1, 1982:			
In Checking Account, Security Bank		$ 4,112	
In Reserve Account, Security Bank		18,119	$22,231
RECEIPTS:			
Dues — Active Members	$10,428		
Dues — Associate & Foreign Members	8,117		
Registration Fees	950		
Advertising Revenue	21,809		
Interest from Security Bank	967		
Miscellaneous	200		
TOTAL RECEIPTS		$42,471	
EXPENDITURES:			
Convention, Publication and Travel Expense	$21,288		
Office Expense, Office Assistance, Supplies, Postage, Stationery and Payroll Taxes	21,023		
TOTAL EXPENDITURES		42,311	
EXCESS OF RECEIPTS OVER EXPENDITURES			160
CLOSING BALANCE DECEMBER 31, 1982			$22,391

The above balance is in a NOW account at the Security Bank. The former Reserve Account was transferred into the NOW account on July 12, 1982.

APPROVED:

F. D. Bruner — President

R. R. Holmes — 1st Vice President

Approved this 5th day of April 1983, Chicago, Illinois

SECRETARY KOERNER: Thank you very much. That applause is appreciated.

I would like to talk a little bit about the condition of the Association. The combination of mergers and early retirements is having its effect on the LMOA official family. In the recent past it took a railroad career to go from commiteeman to President of the Association. Now, with the attrition rate greatly accelerated, it appears a successful candidate can make the trip in half the time.

For a strong and successful Association it is necessary that our officers have a full grounding in committee work, service as a regional executive, before stepping up to the officer ranks. To ensure this, we are going to have to strengthen our request of railroad managements to nominate competent men for committee assignments, a commitment in okaying vice chairmen of committees, so that we can reasonably expect them to continue on through the steps of committee chairmen, through the officer ranks, and on to President.

In conjunction with the foregoing we also plan an early contact of all CMOs to establish a membership chairman on each of their railroads in order to get our membership drive off to a strong start this coming year. I feel that these are some of the areas we have to address this coming year, and if anyone has any questions or comments I would like to hear them. If not, that is my report. Thank you.

MONDAY AFTERNOON SESSION

September 19, 1983

REPORT OF THE COMMITTEE ON DIESEL MECHANICAL MAINTENANCE

WILLIAM A. BROWN, Chairman
Superintendent Motive Power
Burlington Northern Railroad
St. Paul, MN

DALE H. PROPP
4th VICE PRESIDENT
Chief Mechanical Officer
Burlington Northern Railroad
Billings, MT

MR. PROPP: Thank you, Joe, for all the hard work you are always doing.

Now will the Committee on Diesel Mechanical Maintenance please come to the platform. We will begin the afternoon session.

[Mr. Propp introduced Mr. W. A. Brown, Superintendent Motive Power, Burlington Northern Railroad, St. Paul, Minnesota. Mr. Brown then introduced the members of his Committee. The report was summarized as follows:

[Introduction, by Mr. P. A. England, Manager Locomotive Maintenance - Mechanical, Conrail, Philadelphia, Pennsylvania.

[Part II, on Torquing Recommendations, by Mr. R. M. Burk, Manager Locomotive Heavy Maintenance, Amtrak, Washington, DC.]

MR. BROWN: Are there any questions on this part of the report?

VOICE: I noticed that in a couple of instances you are recommending retorquing specifically crab nuts and head bolts on a periodic basis. Do you mean retorque or do you mean check torque?

MR. T. G. WINFIELD [Assistant Manager Technical Service, EMD, LaGrange, Illinois]: The

EMD 645 engine — the crab at the first 30-day tightness check is a check of the crab system. Annually thereafter it is a loosening and retightening.

[The section on Update on Fuel-Efficient Locomotives was summarized by Mr. A. K. Jordan, Supervisor Diesel Engines, Union Pacific Railroad, Omaha, Nebraska, Vice Chairman of the Committee.]

[The section on Radiator Screens was summarized by Mr. J. M. May, Superintendent Locomotive - Mechanical, Illinois Central Gulf Railroad Company, Chicago, Illinois.]

MR. BROWN: Are there any questions concerning cooling screens?

MR. STAROSCHAK: Concerning the wide screens, who are the manufacturers who make that screen?

MR. BROWN: Diesel Radiator Company.

MR. STAROSCHAK: What is the recommended interval to changeout and cleaning the screen?

MR. BROWN: Which type of screen are you referring to?

MR. STAROSCHAK: The wide screen.

MR. BROWN: From 12 to 24 months. We found it varied depending on water treatment.

MR. STAROSCHAK: One last question not directly related to screens. You are familiar with the flat round mechanical bonded radiators. I am wondering if in your opinion that is less susceptible to plugging than the typical soldered radiators. The mechanical bonded is called the flat round, instead of having that angular hole. We have a round hole at the head.

MR. BROWN: On our railroad, the Burlington Northern, we retrofitted our fleet of 45 Series with mechanical bonded radiators, and we began that program around 1976 or 1977. At that time we installed screens, the sandwich type screen or header screen, in all of them, and to my knowledge we have never seen plugging on them. We have had some screens plug, of course, but that is a maintenance item. Those radiators were always protected on our railroad. I can't speak for others.

VOICE: What are some of the initial indicators relating to a plugged screen?

MR. BROWN: There are various methods you can use to check it. You can take measurements in the cooling system. I don't know of any railroad that has that in their scheduled maintenance program. The engine would run hot, I would assume. There are ways of checking that with pressure readings. You will know if the screen is getting plugged. It changes the water pressure in the cooling system.

MR. C. D. NORRIS [Supervisor Quality Control, Chessie System Railroads, Cumberland, Maryland]: The Chessie System has a method for detecting plugged cooling water radiator cores or screens by monitoring water pump discharge pressures.

A male, quick-disconnect fitting was installed in both water pump discharge lines for obtaining water pump pressure readings.

With engine running at normal operating temperature in the 8th notch - No Load - observe the water pump pressure. Normal readings will be 40 psi in low horsepower, 50 psi in medium horsepower, and 60 psi in high horsepower units.

An increase of 5 psi above normal working pressure indicates a back pressure caused by restriction in the cooling system.

Pressure readings are taken once a year to prevent premature engine failures due to plugged screens or radiator core tubes restricted.

VOICE: Is borate part of the problem we are seeing here?

MR. BROWN: Perhaps one of the treatment representatives would like to comment. I know that lack of the proper treatment will adversely affect any locomotive cooling system.

MR. GEORGE BECK [Dearborn Chemical Company, Lake Zurich, Illinois]: I think the question is specifically related to borate solubility. I would seriously doubt that. The insolubles you get into primarily are going to be hardness or corrosion product. That would be the result of hard water or insufficient or ineffective cooling water treatment. That is not to question the basic solubility of borate.

PRESIDENT BRUNER: I am not going to ask a question.

The mechanically sealed radiators on the 610 locomotives we had on our property came in in 1969 and are in storage now. They did have the round tube, very expensive radiators made by EMD, but to my knowledge in all the time I was around we never took those radiators off because of plugging. The larger tube took care of that. That might answer part of the question. They ran for almost 15 years with no trouble.

MR. BROWN: If there are no further questions or comments we will continue with the last part of the paper.

[The section on Alternative Starting Systems was summarized by Mr. R. W. Vitek, Assistant Superintendent Motive Power, Chicago & North Western Railroad, Chicago, Illinois]

MR. BROWN: Are there any questions concerning the alternative systems? If not, I will ask Mr. Kuhns to summarize this paper.

MR. J. L. KUHNS [Manager Planning & Maintenance, Seaboard System Railroad, Inc., Jacksonville,

JACK L. KUHNS
REGIONAL EXECUTIVE
Manager Planning & Maintenance
Seaboard System Railroad
Jacksonville, FL

Florida]: Thank you, Bill. Again I think you have done a wonderful job. You have picked five timely subjects.

Water leaks, lube oil and fuel system leaks have plagued us since day 1 on locomotives. You have given us a challenge to build a locomotive that we don't have to continue to keep tight.

I think the importance of radiator screens has been brought out very well. As locomotives move from one end of the country to the other, the type of water they use is quite variable, and screens become plugged. A lot of railroads disregard screens, and just remove them. This points out the necessity of keeping them clean and checking the locomotive to be sure it is performing properly.

Starters is a controversial subject. I have always thought we carried a lot of batteries to do nothing except crank the engine. With the advent of fuel conservation, shutting down locomotives when not in use, we have to have a reliable piece of machinery—air, batteries, hydraulic, or whatever.

The importance of torquing is very important and is long overdue. Torquing is extremely important and will continue to become more and more important. We ask more and more of locomotives and engines. Torquing is extremely important. I think this is a very important subject. It has a lot to do with the kind of leaks we are trying to control.

Fuel economy update is also very timely. We are all trying to save fuel. With the advent of EMD and GE and Bombardier, I am sure they have the same thing in mind also.

I will now turn the meeting back to Mr. Propp.

MR. PROPP: Thank you, Jack, for that summary. Thank you, Bill, and your Committee for an excellent presentation. Thanks also to this very attentive audience. I hope you have enjoyed it.

Frank Bruner said in his presidential address earlier that he was proud to be associated with LMOA, and he mentioned this was the highlight of his career. I want to say, Frank, that all of us have been proud to be associated with you. We know that you have contributed a lot to the LMOA, the Union Pacific and the entire railroad industry. I know of no one who is more creative in his thinking. So, Frank, we are all proud of you and appreciate your fine performance as President of LMOA. [Applause]

PRESIDENT BRUNER: Thank you, Dale, for those remarks.

I don't have any special announcements. We will begin again at nine o'clock in the morning. I hope you will all stop at the hospitality suites this evening.

Now let's all stand and give Bill Brown and his Committee a rising vote of thanks.

[The audience arose and applauded.]

[The meeting recessed at 3:35 p.m.]

TUESDAY MORNING SESSION
September 20, 1983

REPORT OF THE COMMITTEE ON DIESEL MATERIAL CONTROL

FRANCIS A. BLUNDON, Chairman
Regional Manager Material
Burlington Northern Railroad
St. Paul, MN

DARRELL M. WALKER
2nd VICE PRESIDENT
Diesel Superintendent
Southern Railway
Atlanta, GA

The meeting reconvened at 9 a.m., Mr. Frank D. Bruner, President, presiding.

PRESIDENT BRUNER: Good morning.

We are going to have another fine presentation this morning on materials, and I am going to call on our 2nd Vice President, Mr. Darrell Walker, to be the officer of the session. Darrell, will you please come up and take over?

MR. D. M. WALKER [Diesel Superintendent, Southern Railway, Atlanta, Georgia]: Thank you, Frank.

The man I am introducing this morning is typical of the people following through the ranks of the LMOA. Sometime during the past year I am sure he was told all of a sudden that he was now Chairman of the Diesel Material Control Committee. It might have come as a shock, but we always have someone who can take over.

[Mr. Walker introduced Mr. F. A. Blundon, Regional Manager - Material, Burlington Northern, St. Paul, Minnesota. Mr. Blundon then introduced the members of his Committee.]

MR. BLUNDON [continuing]: I want to take just a moment to express a word of thanks to the members of the Southwestern Railway Club. They were very gracious hosts for our pre-convention presentation of the 1983 paper at the spring meeting of their Club in Little Rock, AR.

The Diesel Material Control Committee is somewhat unique in its makeup. It consists of a mix of personnel from both the mechanical and material departments. The members use their particular expertise to address the broad spectrum of material concerns which are of interest to railroad management.

For example, here are some subjects addressed in past years: 1976, Profitability and Warranty. 1977, Production Stops — Causes and Cures. 1978, Problem Solving Through Analysis and Projection. 1979, Material Management — Dollars Saved Through Efficiency. 1980, Locomotive Material Management — What Lies Ahead in the '80s. 1981, New Innovations in Material Handling and Control. 1982, Maintaining Product Quality Through Improved Material Handling.

Continuing in this line of important considerations, the theme of the 1983 Diesel Material Control Committee paper is Material Systems — Action Through New Ideas.

[The report was summarized as follows: Part A, by Mr. L. S. Conti, Manager Renewal Parts, General Electric Company, Erie, PA.

[Part B, by Mr. M. L. Tataroff, Electrical Engineer — Locomotive, Illinois Central Gulf, Chicago, IL.

[Part C, by Mr. T. H. Field, Director Regional Material Control, Southern Railroad, Atlanta, GA.

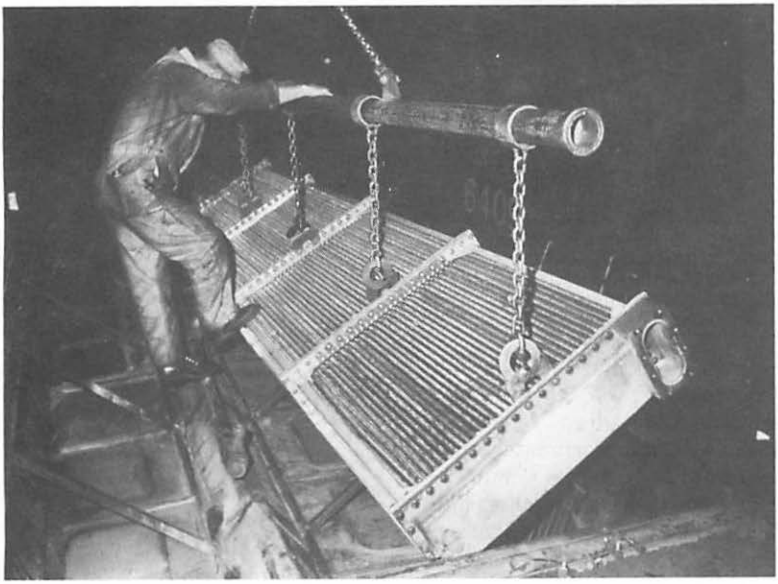
[Part D, by Mr. W. R. Powell, Material Supervisor, Atchison, Topeka & Santa Fe Railroad, Topeka, KS.]

MR. BLUNDON: Are there any questions on any part of our paper? If not, I would like to thank you for your attention. The Committee is still in the process of planning our 1984 paper, and we solicit your ideas for topics. I have asked some members of the Committee to move among you and distribute some cards. If you have any suggestions for topics for next year, I would like you to complete the card and return it to me or any member of the Committee during the rest of the meeting.

Again I would like to express the thanks of the Committee to you for your attention and attendance. Thank you.

Now I would like to call on Mr. Don Ward to summarize the paper.

MR. DON L. WARD [Coordinator Shop Methods, Burlington Northern, Springfield, Missouri]: At this time I would like to summarize the Committee's report, but before doing so I would like to take a few moments to extend my personal thanks and the thanks of the LMOA to two people who have been associated with this Commit-



DONALD L. WARD
REGIONAL EXECUTIVE
Coordinator Shop Methods
Burlington Northern Railroad
Springfield, MO

tee for many years. They were on this Committee when I was its Chairman, and unfortunately they were forced to leave the Committee due to changes in their job assignments. They are LeRoy Showers, Union Pacific, our Vice Chairman for many years, and Mike Wall, of the Missouri Pacific, who has served as Chairman of the Committee for the past two years. These gentlemen will definitely be missed. Again, on behalf of the LMOA I want to thank them for the job they did for so many years for this Committee.

Mr. Blundon and his Committee are to be commended on an excellent job this morning. The procurement of locomotive repair material has always been a weak link in the locomotive maintenance chain. The work that has already been done and is continuing today by the railroads and the suppliers, to improve the flow of repair material so the locomotive maintenance officer can do a better job, is both commendable and in some cases, such as the one on computerized data transfer, exciting.

The Committee has definitely given the maintenance officers some food for thought in their ongoing efforts to have repair material on hand when it is needed, while at the same time keeping the railroads' dollar investment to a minimum. We have been presented with some of the various options available in setting up our material management systems, providing us with the necessary information to see which system is best suited to our individual railroads. The Committee has also presented us with a look at inbound material inspection so that we, the maintenance officers, can be assured that the repair material we receive will meet quality requirements we expect.

Finally, we have been presented with some of the various containers used for storing our repair material once we have received it in our shops, containers that not only minimize damage but also utilize ever-precious shop space.

Please join me in giving Mr. Blundon and his fine Committee a vote of thanks for a job well done. [Applause]

At this time I will turn the program back to Darrell Walker.

MR. WALKER: Frank, I would like to say thanks for a job well done, and also I would like to start with your first question for next

year — or maybe you can get into it in the What's Your Problem session for next year.

Not many years ago we faced an economic situation similar to what we are in today. Locomotive purchases were deferred. Then with the recovery, which I hope we will see again in the future, came an abundant supply of locomotive orders and a severe parts shortage.

I am wondering if we have plans in the making, both from the supply end and the railroad people, giving some kind of forecast or warning to the suppliers to prevent such a disaster again if we should have a recovery in the near future.

At this time we will ask the New Developments Committee to come forward.

TUESDAY MORNING SESSION
September 20, 1983

REPORT OF THE COMMITTEE ON SHOP EQUIPMENT

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

ELMER R. HAFLING
6th VICE PRESIDENT
Engineering Assistant
Atchison, Topeka & Santa Fe Railway
Topeka, KS

PRESIDENT BRUNER: I would like to call on our 6th Vice President, Mr. Elmer Hafling, Engineering Assistant, Atchison, Topeka & Santa Fe, to act as officer of this session.

MR. ELMER HAFLING: It is a privilege and pleasure to be associated with such a fine group of people who represent the Shop Equipment Committee. They are consistently on the move in presenting new technologies and new methods of maintenance of locomotives and existing and new shop equipment. This is important today because we have to have high quality control with increased output along with reduced expenditures.

The Shop Equipment Committee is chaired by Paul Hoerath, Superintendent Plant Engineering, Consolidated Rail Corporation, Altoona, Pennsylvania.

[Mr. Hafling introduced Mr. Hoerath. Mr. Hoerath then introduced the members of his Committee.]

MR. HOERATH [continuing]: I want to acknowledge and thank Conrail for hosting the pre-convention presentation at Altoona, as well as the interesting shop tour of the Juniata Locomotive Shops.

[Mr. Hoerath read the Introduction of the paper. The paper then was summarized by Mr. R. V. Propp, Shop Superintendent, Burlington Northern, West Burlington, Iowa; Mr. J. R. Snowden, Shop Engineer, Illinois Central Gulf Railroad, Paducah, Kentucky; Mr. M. G. Marler, Mechanical Superintendent Shops, Union Pacific Railroad, Omaha, Nebraska; Mr. W. R. Doyle, General Foreman, Missouri Pacific Railroad, Kansas City, Missouri; Mr. K. O. Anderson, Manager Customer Support, General Electric Company, Erie, Pennsylvania, and Mr. L. G. Salts, Engineering Assistant, Santa Fe, Topeka, Kansas.]

MR. HOERATH: That concludes the presentation of our paper. Are there any questions from the floor?

MR. PROPP: I have one question regarding the manufacture of our own gear cases. Does the Committee have any economic analysis of that procedure with the robotic equipment?

MR. MARLER: I am not going to give the exact costs to produce a gear case, but I will tell you that you can't justify buying two presses, one plasma arc cutter and a robot to build gear cases for your railroad.

If you already own a press and a cutter, you can purchase a robot, and by using just that machine the time necessary to build cases, you can produce gear cases cheaper than you can buy them.

You could buy an automatic welder instead of a robot that would do just the one job of welding a gear case cheaper than you can buy a robot, but the advantages of having a robot are:

(1) You are learning the new robot technology that is surely coming.

(2) Not only will it weld gear cases, but it can be programmed to make many other components such as we showed on the slides.

We do not intend to become a profit center and sell cases to other railroads.

Another advantage in making your own parts is that the more we make, the more it seems to lower prices from other sources, so all railroads reap an advantage when one does something like this.

VOICE: I am interested in the cost of some of the Tame machines that were shown—the work bench machines. I wonder if the Committee studied the point where the volume of work in a given shop would justify the purchase of some of these machines. I didn't hear anything about the type of shop, heavy backshop repair where a lot of production is done, or a running repair shop where some of these machines could be used or justified.

MR. HOERATH: I think I can answer part of that. Your wrenches most certainly can be used in a running repair shop to great advantage, because you are doing that type of work, where some of the cleaning machines are more for a backshop operation because they are a volume type of operation.

THOMAS A. KESSENGER
Senior Engineer - Facility Planning
Seaboard System Railroad
Jacksonville, FL

I think each railroad or each shop would have to take a look at the cost of a wrench versus savings. That is what we really come down to on this — savings either through better quality or savings in manpower or material, to justify a particular wrench or a particular cleaning machine or whatever specific item we are talking about. You would have to contact the builders and/or suppliers of those products to get the current price.

Are there any other questions from the floor? If not, Tom, we will call on you for a summary of the paper, please.

MR. T. A. KESSENGER [Senior Engineer - Facility Planning, Seaboard System Railroad, Jacksonville, Florida]: Being Chairman of this Committee isn't all that hard, because all the fellows are hard workers and they pretty well know what they have to do.

The anchorman behind the scenes on this Committee, whom we really don't recognize a lot, is Mr. K. O. Anderson.

This paper is a good ready reference for us especially in the area of new tools and also welding qualifications. We can put the book away and can refer to it at a later date. The welding qualification section was a good reference for all the major national organizations producing codes, and also gives us a good standard for qualification of our welders.

The first section, in regard to the locomotive maintenance production line, shows us the current trend of the industry especially in our large diesel points where a lot of engines are sent for monthly inspections to assembly-line this type of procedure. Of course there are a lot of different ways to do it. What type of work do you perform at each station? The big bugaboo is when we wash it. Do we wash it before or after we pull the filters out? There is a lot of discussion in this area. It is a good example of one way to do it.

Mr. Marler covered a very interesting section on robots. We have seen some robot-type things. There is one piece of equipment on the market that loads wheels automatically, and another railroad has something that loads parts into a wash system. This type of equipment is very good in repetitious areas and also in areas where there is a danger or health hazard. I think we will see a lot more of this type of equipment used in the future.

The onboard telemetering instrument is also an exciting area, being able to report on the actual problems and types of problems that are on the locomotive without being dependent on the crew to tell us what they have seen, and sometimes you don't get accurate reports. I am sure the microprocessors used on locomotives will also give us a history. So, we have fine tools to work with in the future.

Mr. Doyle covered a very interesting section. We have always wondered what motivates the people who work for us and with us. I think the idea that we need to have the people involved in setting their own goals and participating and being informed is a very good way to look at it.

Mr. Anderson covered the GE Training Center. It appears that GE has put forth a large investment in money to help train our industry, and I hope our industry takes part and sends people and maybe possibly can even model a few of the facilities they have at their own locations.

I will now turn the meeting back to Elmer.

MR. HAFLING: Thank you, Tom. I would like to add that the tools and machinery that this Committee presents usually are tools that are in the shops of one of the railroads of these Committee members and are being used to advantage to increase their productivity and increase their efficiency of the piece of equipment being repaired. As for the people who manufacture these things, we are not trying to advertise them but are just showing that this or that piece of machinery is available and you, too, can use it to develop your output and increase it if you so wish.

This Committee has kept us informed of the latest equipment that is available today, and I think they have done a fine job.

I will now turn the meeting back to Mr. Bruner.

PRESIDENT BRUNER: I thank you all for your attention. The Committee did a great job. I had a chance to attend a meeting earlier and hear some of the preliminaries. I have read all the information in the book. I just hope you will pass this information on to others on your railroads and take advantage of it. At the same time you might nudge them to see if you can get their membership in the LMOA if they haven't already joined.

I want to thank Mike Wall for the work he has done for the LMOA. I wish him all success. I know he is a very talented man and should do splendidly in his new position.

Now let's give both of our committees this morning a standing vote of thanks.

[The audience arose and applauded.]

[The meeting recessed at noon.]

TUESDAY AFTERNOON SESSION

September 20, 1983

The meeting reconvened at 2:00 p.m., Mr. Frank D. Bruner, President, presiding.

PRESIDENT BRUNER: Good afternoon, and thank you all very much for being here.

We have a little business to take care of. Before I proceed I would like to thank very much a dear friend of ours, sitting down here with her little machine, Charlotte Emmons, who has done a great job of recording for us for many years. I want to give her our sincere thanks. [Applause]

I also want to express my thanks again to Joe Koerner and his wife Lou, for all the work they have done in helping me out in the past year, and the whole LMOA for so many years.

At this point I have the honor of calling to the podium Mr. Dick Holmes, Director of Chemical Laboratories and Environment, Union Pacific. I have worked with Dick for a number of years, and he has worked with me. We have solved a lot of problems in the LMOA, and it has been great. Dick, will you come up here?

I have something here that I wish I had had in the office a few times but didn't have. I would like to pass along to Dick the gavel of the LMOA. I wish you good luck for next year, and I know the Association will be in good hands. [Applause]

[Mr. R. R. Holmes assumed the Presidency of the Association.]

PRESIDENT HOLMES: Thank you, Frank, and members and friends. My notes say I am to make a short acceptance speech.

I accept the gavel, and the position of President of LMOA that it represents, with a great deal of pleasure since it has been passed down to me by my former boss, now retired.

It is with a great deal of pride and a sense of deep humility that I venture into this arena as your President. I realize full well that any degree of success I may attain will be attributable to my great team of officers, committeemen, and the general membership.

I take great pleasure in personally commending Frank Bruner for a job well done during his years of service with LMOA and as its President. Frank was a prime mover in his activity and in his devotion to this organization and the railroad industry. He has always been a source of endless encouragement and help to all those who have worked with him. Frank will still be available to lend a hand with our endeavors in his capacity as Chairman of the Board.

On behalf of LMOA I again want to wish him well in whatever areas he may become involved in during his retirement from active railroad

Newly elected President Dick Holmes, left, accepts gavel from retiring President Frank Bruner. Center is 2nd Vice President Dale Propp.

service, whether it be a continuation of his innovative endeavors or whether it's just "doing his thing" in his leisure time.

I also want to recognize Mr. John O'Neill, Vice President of CNW, who has retired from the LMOA Advisory Board after many years of active participation.

Our thanks also to Mr. Mike Wall, now Chief Mechanical Officer of the Missouri Pacific, for the many years of service he has contributed to the LMOA and for his personal efforts and leadership. It was with great regret that we accepted his resignation on account of the demands of his new position. However, as a member of the Advisory Board I am certain he will not only continue as a staunch supporter of LMOA but will actively participate, as his time allows, in providing guidance and direction in future years.

I would also like to recognize similar contributions to the LMOA by Bill James, Chief Mechanical Officer - Locomotives of the Chessie System, who found it necessary to resign as Vice President of LMOA. His resignation also was accepted with regrets, fully recognizing our loss of his capabilities and his coming succession as President and leader of the LMOA.

We are also losing Elmer Hafling, who was just elevated to the position of 4th Vice President of the LMOA. Elmer has also had a long period of dedicated service in many areas of LMOA.

I am also grateful for the full support of LMOA activities by Mr. Jack McDonough, Union Pacific Railroad Chief Mechanical Officer. Union Pacific has assigned a member to every LMOA committee, with three committee chairmen for the coming year.

At the same time I wish to thank all the other member railroads that also have made significant contributions. Several have continuously hosted pre-convention presentations. Some railroads are also represented on most of the committees and/or have supported those who are chairmen or officers of LMOA. We also deeply appreciate the support of those railroads that are sending members to the convention.

Finally, in regard to those who were the leaders and faithfully served the LMOA in the past, I would bring to your attention the tabulation of Past Presidents and Life members listed on pages 96-97 of your 1983 LMOA Annual Proceedings. This list includes illustrious railroaders who were outstanding in performance, dedicated in their jobs, and dedicated to the LMOA. These leaders have passed on to us a record of significant accomplishments and a tradition of success.

It is with this background of leadership and dedication that we as LMOA members should carry on the traditions and vitality of these past leaders. I will endeavor to perform the tasks of President of the LMOA to the best of my ability, realizing again full well that it is a team effort that will make a successful year for the LMOA.

Each and every member of the LMOA is as much a part of the organization as the ninety people who make up the various committees that do the basic chores, in addition to the Executive Committee group. This is the railroad industry mechanical department's technical forum, open to all to air their own individual views, discuss problems, ask questions, and expect solutions or answers to their questions. We must invite, encourage, and earn the support of the rank and file to ensure the enduring viability of this organization.

Our membership has dwindled at an alarming rate, as reported here yesterday. Considering the economic atmosphere, some problems are expected. However, depletion of our ranks cannot be allowed to continue. At one time LMOA boasted about 4,000 members. In more recent years the membership goal has been 2,000 to 2,500. As of the count yesterday, I believe it was approximately 1,450, down 25 percent from last year. We must endeavor to reach a goal of 2,000. We must continue to justify our management's support by finding better ways and more productive methods that will result in maximum bottom-line benefits.

Santa Fe, Conrail and Amtrak deserve special recognition in reaching their membership goals first this year, with Santa Fe and

Conrail having the largest membership group. Our congratulations to both.

In closing, after reviewing comments made by incoming Presidents and Past Presidents, as well as commentaries during the sessions, I have found these words repeated many times—words whose implications we should direct our fullest and most earnest attention and thinking to. Some of them indicate LMOA's objectives, others relate to the times we are operating in. Some of these "one-liners" are: Membership - Advertising - Communication - Goal-objective - Personal Commitment - Hard working - Studying - Solutions - Better tools - Valuable resources - People - Active - Tradition.

A few of the more somber terms that are more descriptive of our present environment are: Survival - Gloomy - Rocky road - Tough times.

Gentlemen, these are "one-liner" expressions denoting what LMOA is all about. These are expressions that applied in the past and are still applicable today. On the UP we have a slogan, "We can handle it." I know that now and in the future LMOA can handle it, too.

Again, thank you for making me your President for the coming year. [Applause]

PRESIDENT HOLMES: I would now like to call on Past President Bob Clevenger to make a presentation to Frank Bruner.

MR. CLEVENGER: Frank, will you stand, please? On behalf of the members of LMOA, for the many years of service you have given to the LMOA, also for the very good job you did during the past year as President of this organizations, I would like to present to you this desk set which is symbolic of Life membership in the LMOA. Since you have retired from the Union Pacific Railroad, though, I don't know what you are going to do with this on the golf course. Congratulations anyhow. [Laughter and Applause.]

PRESIDENT HOLMES: That is a lovely desk set, Frank, and I am sure you will enjoy it for many years to come.

We have with us our old friend Ky Pruchnicki. He told me he has been around this organization since the 1930's, so I know he will enjoy this little chore of passing on the Past President's pin to Frank.

MR. PRUCHNICKI: Ladies and gentlemen, I have been assigned by the committee to make a presentation to the Past President. Frank Bruner made an excellent President. He worked hard, presented a lot of papers, and the committee members enjoyed working with him. He is well versed in railroading, and he has helped railroading to advance in many phases. May I present this lapel pin to Frank Bruner so he will remember our organization. We will never forget him. [Applause]

PRESIDENT HOLMES: Next, I have the pleasure of calling upon our old friend and associate, for-

Frank Bruner's years of LMOA service, culminating in the presidency for the year 1982-83, are rewarded as he receives the General desk set from Past President Bob Clevenger, right. Smiling his approval, center, is President Dick Holmes.

mer LMOA Vice President and Honorary Life member, Charlie Smith. I think he has a few words to say and a chore to perform up here.

MR. CHARLES M. SMITH [Retired Manager - Mechanical Engineering - Passenger and Locomotive, Consolidated Rail Corporation, Strafford - Wayne, Pennsylvania]: Frank, you have had a very active administration. This is a permanent record of your term as President. Please accept this bound volume of the LMOA proceedings for this year. It is a great honor for me to present this to you. [Applause]

PRESIDENT HOLMES: Next, I will ask these gentlemen to stand and be recognized. We apologize for the fact that the blazers for the new Vice Presidents didn't arrive on time.

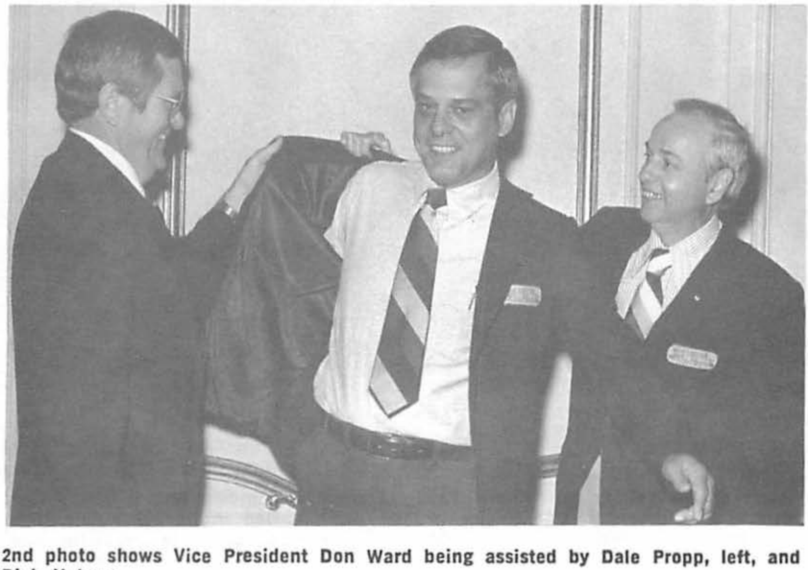
May I introduce our new Vice Presidents, Elmer Hafling, Don Ward and Jack Kuhns. We all look forward to serving with them. [Applause]

Now I will call on 5th Vice President Don Ward, Coordinator Shop Methods, Burlington Northern Railroad, to serve as officer of the session. I will ask the Fuel and Lubricants Committee to come to the podium, please.

Two past presidents mug it up for the photographer. Here Ky Pruchnicki, right, is shown presenting past president's pin to Frank Bruner, while 1st Vice President Darrell Walker, center, enjoys it all.

Left to right: Outgoing president Frank Bruner, Past President Ky Pruchnicki, 3rd Vice President Bud Cumbea and Past President Bob Clevenger. Mr. Bruner is shown accepting the bound record of his term in office.

The tailor fell behind in supply blazers for our new vice presidents, and as a result three had to be awarded at the same time. In the first photo Vice President Elmer Hafling is being helped into his blazer by Dick Holmes, left, and Frank Bruner.



2nd photo shows Vice President Don Ward being assisted by Dale Propp, left, and Dick Holmes.

3rd photo finds Jack Kuhns receiving the finishing touches from Darrell Walker, left, and Bud Cumbea.

Photographed following the Official Family Luncheon, standing left to right: Past President Bob Clevenger; Vice Presidents Elmer Hafling, Don Ward, Jack Kuhns, Dale Propp and Darrell Walker; Past President Ky Pruchnicki, and Vice President Bud Cumbea. Seated, left to right: 1st Vice President Dick Holmes, President Frank Bruner, and Secretary-Treasurer Joe Koerner.

TUESDAY AFTERNOON SESSION
September 20, 1983

REPORT OF THE COMMITTEE ON FUEL AND LUBRICANTS

DONALD D. HUDGENS, Chairman
Manager Field Laboratories
Union Pacific Railroad
North Platte, NE

DONALD L. WARD
5th VICE PRESIDENT
Coordinator Shop Methods
Burlington Northern Railroad
Springfield, MO

MR. D. L. WARD: In 1962, after seeing the size of the Committee and hearing its presentation, I was impressed with the LMOA. I have been a member and have worked hard in the organization since then.

Today we have the Fuel and Lubricants Committee here, and I would like to introduce their Chairman, Mr. D. D. Hudgens.

[Mr. Ward introduced Mr. D. D. Hudgens, Manager Field Laboratories, Union Pacific Railroad, North Platte, Nebraska.]

MR. HUDGENS: I would like to thank you, members of the LMOA, for electing me as Regional Executive effective at the end of this meeting.

Also, a big thank you to the Southern and Southwestern Railway Association for the gracious hospitality extended to the Committee and for the interest they expressed in our paper at our preconvention presentation at Huntington, West Virginia this past spring. Also, to the Chessie System for providing us an opportunity to look at their facilities in Russell, Kentucky.

I also would like to express my appreciation to Mr. Gene Broman, of Arco, who retired this past spring. Gene had been a member of the Fuel and Lubricants Committee longer than many of us can remember. Over the years Gene was very active and made many valuable contributions to the Committee and the railroad industry in the lubrication field. For that we are grateful, and wish Gene the very best in his retirement.

[Mr. Hudgens introduced the members of the Committee. The paper was summarized as follows: Part I by Mr. W. H. Melgren, Manager Springfield Laboratory, Burlington Northern, Springfield, Missouri. Part II by Mr. W. C. Hamilton, Assistant Engineer of Tests, Seaboard System Railroad, Louisville, Kentucky. Part III by Mr. J. L. Wilkison, Products Application Engineer, Shell Oil Company, Houston, Texas.]

MR. HUDGENS: Our paper was in three sections. If anyone has a question we will try to answer it.

MR. JERRY THOMPSON [Amoco Petroleum Additives Company, Naperville, Illinois]: I would like to ask about the multigrade testing. Were the power assemblies from that field test rated for deposits? If so, how did the deposits compare? Also, were used oil analyses obtained, and did they show any difference with respect to wear metals or alkalinity retention?

MR. HUDGENS: You asked if the deposits were rated. No, I don't believe they were. Did you want to know if the wear metal content showed higher in the multigrade? No, they were about the same. We didn't see much difference in the control unit and the multigrade test unit. Wear metal content was about the same.

MR. WESTERFIELD: Some quick arithmetic shows that the condensation temperature for the sulfuric acid is in the neighborhood of 300° at the cylinder wall. Would either of the builders like to comment on what kind of engine cooling water temperature that translates into?

MR. G. C. McCARTY [Technical Engineer, EMD, LaGrange, Illinois]: I can't tell you what it translates into, but at least in marine operation we use a higher Amot valve to keep the cooling water temperature up. We go from a 175 to a 195 Amot valve. In railroad operation we haven't been getting into higher sulfur content. I don't know what the 300° temperature would relate to on the cylinder wall.

MR. J. G. HOFFMAN [Manager Performance and Evaluation, General Electric Company, Erie, Pennsylvania]: You will remember that those curves showed that the condensation temperature varied with percentages of sulfur. You are certainly correct that the order of magnitude of the cylinder wall temperature is 350°F to 360°F. The best translation I can give you, as far as the GE engine is concerned, is that if you keep the water jacket temperature above 160°F you will prevent any significant condensation of sulfuric acids. That is essentially the equation,

but it is not truly the specific equation that you asked for.

MR. PATRICK LI [Imperial Oil Company of Canada, Windsor, Ontario, Canada]: I would like to make a brief comment on the wax crystalloid modifier that was mentioned briefly in the presentation. I feel it is a very powerful additive and very new, and probably deserves more emphasis and more attention. I wonder if many railroads are using this particular additive at the moment.

MR. HOFFMAN: I think the question is whether any railroads are using those pour point depressants. My inclination is that if they are, they may not know it, since those particular types of materials would likely be added by the oil company at the refinery, so probably the question should be more properly directed to the petroleum industry.

I am aware of certain test work that has been done by petroleum companies. Whether it was that specific additive that the question was addressed to or not, I don't know. I was not directly involved.

Does that help you? Does it help clarify your questions?

MR. LI: Yes.

There is another point I would like to make, that the pour depressant is not quite the same as the wax crystal modifier. They are separate, although one might influence the other. They are quite separate additives.

MR. HOFFMAN: Since that microphone is picking up so poorly, at least as far as this table is concerned, I am going to repeat what I think you said for the benefit of the audience. You made the point that the wax crystal modifier is a distinction and is different from a pour point depressant, per se, and that that should be kept in mind. I concur with that.

MR. LI: That's right. Thank you.

MR. D. G. GOEHRING [Manager, Equipment Maintenance Planning, National Railroad Passenger Corporation, Washington, D. C.]: I have a question directed to the petroleum members of the panel.

I heard a comment about the availability of #1 versus #2 fuel, or a comment alluding to an availability difference of #1 versus #2. In the event of a fuel emergency today or in a 20-year outlook assuming today's consumption of fuel oil stays constant, is the ratio of #1 to #2 availability going to remain about the same as it is today, or will there be a difference?

MR. HUDGENS: Jim, will the ratio of #1 to #2 availability vary or will it come out of the barrel the same?

MR. J. L. WILKISON [Staff Engineer, Shell Development Company, Houston, Texas]: I can only speculate. The lighter the products out of the barrel, the more valuable they are. I think it would depend on the success of the aviation industry. Aviation gas turbines cannot run on lower quality fuel. Your

diesel engine can run on a fuel of lower quality than ASTM 2D, but jet engines cannot tolerate fuel quality decline. When you are flying people you must have fuel that meets the specifications.

So, what happens if there is a shortage of distillate? I would say the #1 fuel or jet fuel would take top priority over the #2. In cases of shortage I would say that the #1 will be in shorter supply for the railroad industry. In a long supply situation, then it probably would be available.

MR. LI: Listening to the presentations on especially the first and second sections of the paper, is it too simplistic a conclusion to draw that, compared with multigrading and blending of residual into #2 , in multigrading we have seen that there is no failure during the test, and there is no compromise in the durability of the engines, whereas on the other hand, with the blending, there are failures and also the availability is shortened. That means that multigrading seems to be the way to go, and one has to concentrate efforts on either one of them; then one will go for multigrading.

My question is: Is it an oversimplified conclusion to draw?

MR. HOFFMAN: Yes, I think it is an oversimplification. I think it is not an oversimplification of the results of this specific test, but it is an oversimplification in the sense of the future.

No. 1, the projected potential fuel cost savings for multigrading is an order of magnitude, on a duty cycle, one percentage kind of number (and please don't hold me to that precise number), whereas the blend, if defined loosely as approximately 20%, shows a cost differential of 6 or 6.5 cents or something of that order of magnitude. Therefore, on a cost basis alone the potential is quite different.

No. 2, one needs to understand the comment near the end of the presentation with respect to multigraded lubricants, namely, that there is a long way to go, and secondly the test showed no statistically different wear, and so on, in the 4-cycle engine in this particular operation.

One must recognize, I think, that in so far as a 4-cycle engine tested is concerned, it was hardly the state of the art level of horsepower or state of the art in ring configuration, or things of that nature, all of which can upset the delicate balance that I am sure you know as an additive developer, that has to go into formulations of VI improvers.

So, to conclude from our paper, in my personal view while we are nearly there with multigraded, and we still have a lot of problems with blended fuels, it would be a major oversimplification to say, "Go with multigrade at the expense of blended fuel." Someone else on the panel may wish to address that.

MR. McCARTY: I would like to comment as far as the multilube oil is concerned. In the tests we were involved in the engines did look pretty good, and there were no heavy deposits.

I don't believe the multilube oil has been tested on a silver insert bearing engine yet. This bearing is one of the most critical areas that must be lubricated. I think this project is in the works for the coming months, but at this time I don't believe the multilube oil has been field tested on the silver insert bearing.

MR. GORDON D.S. HAMILTON [Gulf Canada, Ltd.]: To address the final point by Mr. McCarty, the audience should know that the field testing of our SAE 20W-40 multigrade engine oil has now completed 2½ years' freight service in recent design non-silver bearing engines and 6 months in silver bearing engine service. Field testing is expected to be completed by November, 1984.

MR. HUDGENS: Any other questions or comments? If not, I will turn the meeting over to Mr. Clevenger. If you gentlemen have any other questions that come to your mind, please save them for the What's Your Problem panel tomorrow, and we will try to answer them at that time.

MR. R. G. CLEVENGER [General Electrical Foreman, Atchison, Topeka & Santa Fe Railroad, Kansas City, Kansas]: Thank you, Don. I think Don Hudgens and his Committee have done an exceptional job this year in putting together a paper which is very dear to the hearts of all the present-day railroad managers.

ROBERT G. CLEVENGER
PAST PRESIDENT
General Electrical Foreman - Retired
Atchison, Topeka & Santa Fe Railroad
Kansas City, KS

The idea of fuel savings, no matter how small, is certainly welcome on all railroads. The Committee has shown what can be expected in fuel savings when multigrade lubricating oils are used, and also what mechanical problems might be encountered. Additional testing along this line is still going on, and I expect additional information will be coming from this Committee in future years.

Residual fuel blends were pointed out as having the greatest potential for cost savings. The locomotive manufacturers recognize this, and have issued specifications and guidelines covering the use of these fuels.

During the talk by Dr. Paul Reese, of GE, this morning, in one of the other meetings, he stated that presently they are experimenting with a 30% blend of residual with 70% #2 diesel fuel, and claimed that if successful this could result in a 10% saving. When you stop to think about the railroads that are burning up to a million gallons of fuel a day, this could be $100,000 or $36 million a year in savings. So, it is quite substantial, this blending of fuels, in the way of cost savings.

Again I want to compliment this Committee on a job well done. I will now turn the podium back to Mr. Ward.

MR. WARD: Thank you, Bob, and I agree with you that it was a fine paper.

Now I will turn the meeting back to Mr. Holmes for his closing remarks.

PRESIDENT HOLMES: Just a few closing remarks before we recess. Don't forget the What's Your Problem session tomorrow. I am sure all the committees will do their best to answer whatever questions you have in mind. Also, note that in the morning we will begin at 8:30 a.m. sharp.

Now let's give a rising vote of thanks to this Committee.

[The audience arose and applauded.]

[The meeting recessed at 4 p.m.]

WEDNESDAY MORNING SESSION

September 21, 1983

REPORT OF THE COMMITTEE ON DIESEL ELECTRICAL MAINTENANCE

JOSEPH KUZELA, Chairman
Engineer Design
Union Pacific Railroad
Omaha, NE

JACK L. KUHNS
6th VICE PRESIDENT
Manager Planning & Maintenance
Seaboard System Railroad
Jacksonville, FL

The meeting reconvened at 8:30 a.m., Mr. R. R. Holmes, President, presiding.

PRESIDENT HOLMES: Good morning to all of you. Frank Bruner presented me with the gavel, but I guess he took it back. I don't have a gavel to bang this morning as we bring this session to order.

At this time I will ask the 6th Vice President, Jack Kuhns, Manager, Planning and Maintenance, Seaboard System Railroad, Jacksonville, Florida, to do the honors in introducing Joe Kuzela and his Committee on Diesel Electrical Maintenance.

[Mr. Kuhns introduced Mr. Kuzela.]

MR. J. E. KUZELA, JR. [Engineer Design, Union Pacific Railroad, Omaha, Nebraska]: Thank you, Jack. The LMOA Committee on Diesel Electrical Maintenance welcomes all of you, and we are pleased to have you attend our session. I would like to thank the Union Pacific System for their support in hosting our pre-convention presentation on April 7, 1983 at the Red Lion Inn, Omaha, Nebraska.

[Mr. Kuzela introduced the members of his Committee.]

[Part I was summarized by Mr.

K. R. Keller, Assistant General Foreman Locomotive, Burlington Northern Railroad, Overland Park, Kansas.]

MR. KELLER: Are there any questions?

VOICE: In the section where you referred to the reduction of horsepower with leakage current, which specific devices do you refer to?

MR. KELLER: The devices I am referring to are on EMD locomotives. Vapor Corporation had a device that was labeled "ARL," and that was used to detect the leakage current in the ground relay circuit. It would de-rate the horsepower by means of bleeding off the rate control capacitors. I don't know how many railroads use that device. It was used on the former Great Northern Railroad and was discontinued because even though it did its job, it was out there working and was not reported by crews. They were operating locomotives at partial horsepower, and the locomotive would come in to the maintenance facility and end up going back out in the same condition.

The other device I am referring to was built by General Electric recently. Burlington Northern put it on some Type E excitation U33s and it worked very well, and you could adjust it so that the ground relay would trip at whatever value you wanted to adjust it for. You could also adjust it so that the horsepower would de-rate down to as low as 200 HP if you wanted it to before the ground relay would trip, and there was a light in the cab that would glow. The glow would intensify as the horsepower backed off. That worked very well. We had reports from the crews, and it was very helpful.

In favor of that method of running a locomotive at partial horsepower, what we did to the rest of the fleet was that we increased the value at which the ground relay would trip. I would prefer to go back to the other method of running the locomotive at partial horsepower. I would like to see that incorporated in a monitor system so when a locomotive came in from the road the shops could see for themselves what happened, and would not have to rely on a crew report.

[Part II was summarized by Mr. N. Thibodeau, Senior Electrical Engineer, Canadian Northern, Montreal, Quebec.]

MR. THIBODEAU: Are there any questions?

MR. R. W. VITEK [Assistant Superintendent Motive Power, Chicago and North Western Transportation Company, Chicago, Illinois]: Concerning the Japanese motors, how long have you been running them, and what kind of service problems have you encountered to date?

MR. THIBODEAU: They went into service in January 1983. Around May or June of this year, after five months in service, we had our first failure—a hot suspension bearing. We are not too happy with the suspension bearing arrangement. The main problem is

that they use too much oil. They don't have the groove in the bearing and the hole that returns the oil to the axle cap, so we decided to make them more or less the same as our standard motors.

We are in the process now of reboring the axle bores of the Hitachi motors, making it the same size as our standard GE752 axle bores, so we can use the same bearings and the same wicks that we get from Miller Felpax. Once this problem is overcome, I believe we will have a good motor.

Electrically we had no problem with them. The motors have been in service for about six months. They were removed from the locomotives for this modification program which should be completed in a matter of weeks. I would say that a month from now they should be under locomotives again. We have 10 Hitachi motors and we are buying another 15 next year. We just placed the order. 10 motors are a small sample on which to run a test.

[Mr. T. D. Lemons, Assistant Supervisor Locomotive Equipment, Missouri Pacific Railroad Company, St. Louis, Missouri, summarized the section on Locomotive Storage.]

VOICE: Have you had any records of how the locomotives perform when they are removed from storage?

MR. LEMONS: Fortunately, we are putting some locomotives back in service in March. When we were in Omaha one railroad had been tracking approximately 20 locomotives that were stored for an average of seven months, and the locomotives were tracked for four months for failures. At that time we came up with 49 chargeable delays on those 20 locomotives, which included GE and EMD. The major cause at that time was that the cylinder head water pump seals had hardened. When the locomotives were put back in service evidently we didn't make a high pressure water test on them. The 49 chargeable delays were recorded as 29 mechanical failures, six electrical, 10 air, and four were charged to traction motors and generators.

Those 20 units have been in and out of storage since then, but we did pick up 10 other locomotives which were GE U30Cs and SD-40-2s. These locomotives were stored for an average of about seven months. Since the recommendation for pressure testing the locomotives, we see our water leaks have decreased, but on the power contactors on the SD40 and U30C type locomotives we are having to dress up some of the contact tips due to corrosion.

At this time those 10 locomotives have had 16 electrical failures chargeable to delays, and 50 percent of them were charged out to power contactors and relays. The mechanical delays were 16 on the engine, three air, and three to the rotating equipment on traction motors and generators.

So, I feel we are headed in the right direction with our stored locomotives, but it is something you have to keep up with or it is going to creep up on you pretty quickly if you don't properly prepare your engines when you store them.

VOICE: Did you have any difficulty with pneumatic contactors that were stored and removed?

MR. LEMONS: Yes, the U30Cs. We had three of those 10 that were pneumatic contactors. Those were actually the failures. We had to dress up the tips and lubricate some of the armature arms. We had quite a few relay problems with those, too, with the tips on the relays. We now put a unit back in storage and we check all of the relays, take all the covers off, and make sure we do have good contact with the interlocks.

[Mr. A. E. Bridges, Supervisor Locomotive Maintenance, Chessie Systems, Huntington, West Virginia, summarized the section on Water Cooling & Refrigerating Methods for Locomotive Cab Application - What Direction Should be Pursued?]

MR. BRIDGES: Are there any questions? [No]

MR. KUZELA: If there are no further questions, I will ask Tom Westerfield to summarize our paper.

MR. GOEHRING: Before we call on Tom, I have two questions relating to the traction motor presentation, i.e., rebuilt traction motors.

When you rebuild or remanufacture your traction motors and put them on the test machine, approximately what percentage of failures are you experiencing as a result of the testing?

Secondly, how does the cost of this compare with unit exchanging the traction motors with the manufacturers?

MR. THIBODEAU: We had very few rejects on the "Becker" tester, if we are talking about the remanufactured motors only. Out of 225 that we produced last year, in 1982, the reject rate was probably not more than 10 percent, and the major reason for the rejects was vibration, bearings that were probably not applied properly, or a couple of bearings were defective and had to be changed out.

To answer the second question, about cost, our cost right now in 1983 to produce a remanufactured motor in our own shop is around $30,000 Canadian. If you convert that to U. S. dollars it would be about $24,000. You have to remember that parts are a little more expensive in Canada.

In 1983 we are not getting any motors from GM, but last year we bought brand-new motors from GM and they were very expensive —close to $40,000 American dollars. For 1984 we have a firm price from EMD or GM for a rebuilt motor. It is not really a unit exchange. They will re-use the frame. All other components will be replaced, and they will return the same motor to us fully remanufactured to D87 standards. I am not quoting exact figures, but it will be approximately $36,000 Canadian. Our cost will be just over $30,000, so the difference is very small between the motors we do in our own shops and the ones we get from the outside. If you consider that we will get from EMD a one-year warranty, we will have to start looking at our efficiency and we will have to see how we can bring our price down. It is good to have competition.

MR. GOEHRING: I might add that I was very impressed personally by the care and precision with which you did that. I don't recall ever having seen anything quite so good. Thank you.

MR. KUZELA: Are there any other questions from the floor? Tom, will you summarize our paper now, please?

MR. WESTERFIELD: There are a fair number of people in this room who can understand my feeling when I say it is with great pleasure that I summarize the paper this year rather than give it. There was a great deal of work involved in putting this paper together, and these gentlemen up here have given a lot of time and effort over the last year to put the presentation together this morning.

In particular, over half of the paper was devoted to two topics—problems with ground relays and problems with traction motor overhaul. There also was continued reference to the problems associated with winter operation. Failure rates increase during winter operation, ranging from a doubling of the failure rate to as much as four or five times the normal failure of traction motors during winter operation. In spite of all the help we talked about, the challenge remains to the railroads and builders to work together to develop locomotive designs that will perform better under winter conditions.

The problem of locomotives being returned to service from storage is one that is going to be facing most of us more and more over the next few months, and the Committee is to be commended for the work they have done on this point. I would urge them to continue over the next year to gather the experience in returning locomotives to service from storage so that we can improve our procedures should we be forced into one of these situations again.

It seems difficult to think about the problems of cooling water on a morning like today. The problem would more likely be getting it warm enough to dare put your fingers in it. The Committee has done a good job summarizing the history of water coolers and summarizing what the prosepects for development should be.

At this point I would like to call for a vote of thanks to this Committee in appreciation of their efforts. [Applause]

MR. KUHNS: This was a very informative paper.

Now we are getting down to the part of our program everybody anticipates. Let's ask the technical committee chairmen to come up so we can start the What's Your Problem session.

WEDNESDAY AFTERNOON SESSION
September 21, 1983

WHAT'S YOUR PROBLEM PANEL

THOMAS A. KESSENGER, Chairman
Senior Engineer Facility Planning
Seaboard System Railroad
Jacksonville, FL

DARRELL M. WALKER
1st VICE PRESIDENT
Diesel Superintendent
Southern Railway
Atlanta, GA

PRESIDENT HOLMES: I am certainly gratified to see the turnout this morning. The number of people in the audience is splendid. It is indicative of the quality of papers being presented and the interest by the group in general.

We will proceed with the What's Your Problem part of the program. We know you are eager to ask questions. I will call on 1st Vice President Darrell Walker to serve as officer of the session. Darrell, will you introduce Tom, please?

MR. WALKER: Gentlemen, the Chairman of the What's Your Problem Committee is Mr. Tom Kessenger.

[Mr. Walker introduced Mr. Kessenger.]

MR. KESSENGER: Thank you, Darrell. This is the session we have all been waiting for. This is your session, your chance to talk to your peers, the vendors and the manufacturers, and it is probably the most important session we have. I hope everyone will take part and that you have thought about your questions. As a matter of fact, looking back at last year's proceedings, there weren't a lot of questions asked. Obviously a lot of us weren't here last year, so maybe we will have some questions left over from that session.

I would like to open the floor to questions at this time.

VOICE: I am with the Chessie. Our ring gears are starting to be torn up, and we have had about seven on the B side. The starting motors on three of them have been checked out okay. What could be causing this problem?

MR. BROWN: I am not familiar with the problem. I haven't heard about it on our railroad.

MR. WINFIELD: EMD is familiar with the situation on the Chessie. It has recently come to our attention through our field service network, and we are looking at it with them. The thing that comes to mind offhand is the possibility of misalignment of the start motors to the ring gear. This is the first thing we would be looking for. We are talking with Chessie in their investigation.

MR. KESSENGER: I have already fouled up in this new job. I have forgotten to introduce the technical men up here.

Starting on my right, Mr. A. A. Chacon, Union Pacific Railroad, Chairman of the Committee on New Developments. Mr. W. A. Brown, Chairman of the Diesel Mechanical Maintenance Committee; Mr. Brown is with the Burlington Northern. Mr. J. Kuzela, of the Union Pacific, Chairman of the Committee on Diesel Electrical Maintenance. Mr. D. D. Hudgens, of the Union Pacific, Chairman of the Committee on Fuel and Lubricants. Mr. Paul F. Hoerath, of Conrail, Chairman of the Committee on Shop Equipment. Mr. Frank Blundon, of the Burlington Northern, Chairman of the Committee on Diesel Material Control.

Are there other questions?

MR. KUHNS: Yesterday during the Fuel and Lubricants Committee paper, there was a lot of discussion on the blended fuel of several railroads running tests. With all the discussion pro and con, it would appear to me that we would be better off having another specification for fuel, like a #3, that Jim Wilkison mentioned. Are there any feelings along those lines? It seems to me we have a lot of problems trying to use this blended fuel, with compatibility from one railroad to another. Maybe we need to have a #3 fuel.

MR. HUDGENS: It is true, we probably would be better off if we had #2 or #1, but we are not too certain of the future, and what we are looking at is potential fuels of the future. We may have to use blends of residual and #2, methanol blends and other exotic things. They work but they do cause problems. They seem to increase maintenance costs. It may be that the cost tradeoff is worth it when the price of fuel gets extremely high.

MR. KUHNS: We are getting off the subject. Why don't we just call for a #3 fuel spec rather than trying to use the blended stuff? We know we can burn it, but it is going to create a lot of prob-

lems. Why don't we just come out with a #3 fuel spec?

MR. CHACON: One of the problems with the #3 spec is that the economics of burning the blended fuels are very much dependent upon how much #6 you use. We have run a lot of tests with a 10% blend, and if you could just burn that and not see any problems at all, economically it would probably be a pretty good venture. But when you start getting into a 20% blend and start having to do modifications to the locomotives, like adding a dual fuel system and a number of other things, then you want to start looking at a 30% blend. I don't think we know enough yet to really come up with a spec that would cover the most economical situation we would want to be looking at.

MR. KUHNS: I agree, Tony. We have been part of a couple of fuel tests on both the North and South end of our railroad. On one end we had no trouble, and on the other end we did. If we have that kind of trouble from the same supplier, just think what we would have running from your railroad to ours. That is my point.

MR. KESSENGER: Have there been any other railroads that have participated in some of the fuel studies and that have had some experience? Do we have a fuel supplier who would like to comment?

PRESIDENT HOLMES: I don't know if the President should comment on this subject. Since none of the oil suppliers volunteered to comment, I will trade a little bit of the history of a proposed additional ASTM 3-D specification fuel that was considered a couple of years ago. Many of us are familiar with the process whereby such new fuel specifications are reviewed, debated, approved and published. The railroad industry had input, the automotive industry had input, in addition to oil suppliers and various others.

At that time they went through the entire study and review procedure. One industry in particular was concerned about particulate emissions in small diesel engines relative to EPA requirements. The new fuel spec was temporarily shelved due to some of these considerations, as well as those reservations expressed within our industry at the time about degrading the fuel oil quality.

I recall several oil companies at an ASTM meeting stating that they have logistical and manufacturing and storage problems. Comment was made that certain oil suppliers would not make two grades of fuel. If they were going to make a fuel suitable for the railroad diesel engines and other small engines, the product would be #2-D or #3-D fuel oil, but not both. So, there were problems that were not resolved for adoption of a "lower" grade fuel oil.

The Union Pacific and other railroads have been active within the last year or so in looking for sources of what you might call off-spec fuel or fuel blend stocks that slightly deviate from 2-D specification fuel. The deviation may be lower cetane number, longer distillation range, or other. The product could be a component in the process stream used to blend finished #2 fuel or heating oil, or a by-product that some oil companies in certain areas of the country may have in excess at their particular location. They could be looking for a market in those local areas.

It seems that is the direction that the search for more economical but useful diesel engine fuel oil should take now, in addition to whatever progress continues in ASTM and AAR. It would appear to me that on an individual basis, in various parts of the country, railroads should investigate with their fuel suppliers as to availability of such blend stocks in the fuels that are in the mid-distillate range that deviates somewhat from 2-D specification. You would, of course, expect it to be a cheaper price than 2-D fuel oil.

MR. KESSENGER: If there are no other comments in regard to this question, we will move on. We have a few engineers of test in the audience who aren't making any comments. We will leave that question, then.

Is there another question in regard to either electrical or mechanical, or possibly shop facility items?

MR. R. H. SEEMANN [Superintendent Equipment, Amtrak, Washington, D. C.]: I wonder if any of the railroads have any knowledge about applying the E3B injector in an E3 engine without any other modifications. It seems there is a reported 1% fuel saving when using an E3B injector.

MR. KESSENGER: Are there any representatives of railroads who would like to address that question? Surely someone in the room must have tried this. Gentlemen, this is the only time in the whole year that you will have this many people from so many railroads to talk to. This is one of the reasons why our bosses sent us here. You know, they all read the proceedings, too.

MR. BROWN: I don't think we have ever tried that on the Burlington Northern during retrofit to the E3B. We use all of the material. I have no experience with that process.

MR. DAVID FOREMAN [Engine Group, EMD, LaGrange, Illinois]: We don't recommend that. The main reason is that the P pressure engendered by the 1/2" plunger injector is higher than it is with the old E3 injector, and there is a failure of insert bearings as a result of the fire-fed pressure. That is why we recommend when you change from the E3 injector to the E3B injector there is a package that goes along with it that includes putting in the rocky E3B insert bearing.

MR. W. F. HAMBLY [Assistant Superintendent Shops - Locomotive, Atchison, Topeka & Santa Fe Railway, San Bernardino, California]: In Mr. Brown's Committee presentation Monday afternoon on converting for fuel savings, they outlined the components that should be utilized, including the fire ring 16:1 comparison ratio piston. Is the 16:1 compression ratio piston going to be compatible with the chrome plated liner?

MR. WINFIELD: Either the 14½:1 fire ring piston or the 16:1 fire ring piston requires a hub liner or a chrome liner.

MR. STAROSCHAK: I have people visiting me every week with new products for locomotives. I wonder if we could perhaps work a little more together on some of this reinventing of the wheel. There are a lot of products that are worthy of test. We really don't have the manpower to test all of them. I would think if we could get together with our brothers on the Union Pacific or Southern occasionally, and conduct a joint test by three or four railroads, it would save us a fair amount of effort and manpower. Has that ever been considered?

MR. KESSENGER: This is a perfect organization to do that in regard to technical papers. It can be brought up specifically as to what types of items you are talking about, and maybe one of our committees could address that, because we have a fairly wide array of fellows from different railroads. Do you have any specific items you would like us to address?

MR. STAROSCHAK: I am glad you asked that. We view the EMD turbocharger with its roller ramp clutch, and feel the roller ramp clutch has a weak link in the design. We are excited about the Sprag design. I wonder if any railroad has been testing this and what their experience has been with the Sprag clutch.

MR. KUHNS: I can't tell you our experience, but we have a couple running on our railroad. One thing that has a lot of merit to it is that whoever puts the turbo together is guaranteeing the Sprag clutch for 3½ to 4 years, so that ought to be some sort of incentive to EMD.

MR. A. K JORDAN [Supervisor Diesel Engine Maintenance, Union Pacific Railroad, Omaha, Nebraska]: We have two turbochargers running with the Sprag clutch. One now has had one year of experience and the other six months.

MR. JAMES McCLAIN [Vice President - Transportation Products and Systems, Arrowsmith Industries, Los Angeles, California]: Arrowsmith is also experimenting with the Sprag clutch concept. We have two units on test at the present time, one with approximately six months in mainline service and the other with approximately three months in switcher service.

While Sprag clutches have been around for many years and have proven themselves in a wide variety of applications, we are not yet convinced that they will perform reliably in current model EMD turbochargers.

The roller ramp overrunning clutch used by Electro-Motive is a

free floating self centering device which works in unison with the hydrodynamic action of the two journal bearings as they uniformly raise and center the rotating assembly and sun gear shift in the planetary gear drive system during normal operation.

Conversely the Sprag clutch, with its extremely tight (.002 TIR) concentricity tolerance between inner and outer races, inhibits this necessary free floating action and tends to hold the sun gear shaft central in its journal bearing. This in turn forces the compressor journal bearing to carry the entire burden of raising and centering the rotating assembly during each engine start-up. We are unsure what effect, if any, this overload condition will have on bearing life, but it is an area that must be taken into consideration when evaluating the Sprag clutch concept.

In my opinion, it would be a serious mistake for anyone to commit to this concept without at least three or four years of comprehensive field testing, and for a manufacturer to offer long-term warranties at this point is a bit premature. It is very easy to claim that this device will last that long, but in reality the Sprag clutch has only been tried in locomotive service for a year, and I seriously doubt whether anyone at this time can say how long it will last.

When we at Arrowsmith are convinced the Sprag clutch is a viable concept, we will offer them as a fully tested, production-ready device with appropriate warranties. Until that time, however, we encourage further testing, and will be happy to furnish our pre-production units to any railroad wishing to conduct an in-depth evaluation. We in turn will make our facilities available for periodic component disassembly and inspections as desired.

MR. KESSENGER: You have made a good point. This is a good time to ask about the items you have been approached on, and you are wondering about other railroads and their response. Possibly the builders have some thought about it. If so, this is a good time to talk about it.

Are there any other new products that have been introduced that anyone would like to ask about?

MR. CHACON: I would like to address something to EMD and also the Fuel and Lubricants Committee. There has been a lot of discussion about lithium versus sodium grease, and a lot of testing has been done since we talked about this the last time. I would like to ask EMD if they are still firm on their stand or if, based on the results of the Santa Fe test, they are going to change their specification.

MR. HUDGENS: I understand some of the railroads that went to lithium have gone back to sodium. The Santa Fe is now testing, and this is a subject we plan to discuss next year.

MR. E. R. NIEMEYER [Assistant Manager Technical Service, EMD, LaGrange, Illinois]: We are involved with the Santa Fe on that gear lube test with the Texaco gear lube, and at the present time our specification remains the same.

MR. LESTER TARBELL [Texaco U.S.A., Oak Brook, Illinois]: We are supplying the gear lubes in this test which is being conducted on the Santa Fe, and I don't want to preempt any of the results that will be coming forward this year. However, I do think it would be good to mention that some of the interest and some of the concern that is being expressed about the sodium and the lithium soap may well be related to the base oil.

Again I remind people that the soap is in there as a thickener to hold the oil in place, and that is its sole function. A lot of the lubrication has to do with the lubricant (base oil) that you use. I think consistent with this, in the new high horsepower units which have been difficult to lubricate, we have seen the need for EP activity. At least this is indicated in some quarters, and I think in some of our earlier (test) results where people indicated that the sodium soap product looked better than the lithium soap product — you must consider that the base oil viscosities were markedly different. The base oil viscosity for the product with the sodium soap was over 1500 seconds at 210°F. The lithium soap product, on the other hand, had a (base oil) viscosity down in the range of 1000 seconds at 210°F. So, there is more involved here than the soap (type).

We have provided lithium soap products and we have an experimental one which has a high VI, heavy base oil in it. We hope this (product) will be of interest to both (domestic) locomotive manufacturers, and we anticipate that the railroads will be interested in it, too.

MR. D. M. WALKER [Diesel Superintendent, Southern Railway, Atlanta, Georgia]: Tom, I have a question I would like to address to the builders, both EMD and GE. I keep hearing about microprocessors in new locomotives. First, I would like to know what we can expect from the microprocessor type locomotive, and when we can expect test models and production models. Comparing it with your own version of locomotives, would you each make some comments in that regard?

MR. KUHNS: On our railroad we will have two locomotives and I believe they will be built in January and delivered in April. They will be equipped with microprocessors.

MR. DAVID SMITH [Senior Service Engineer, General Electric Company, Erie, Pennsylvania]: On our Dash 8 locomotive we have the unusual problem of having too much information. We are trying to sort through what you really need. We are going to break down the diagnostic display into several levels. The first one will be the same words, "ground relay," "hot engine," and so on. With a suitable password on a membrane key pad, a shop man can then call up another display, and during the load testing he can watch lube oil temperature, horsepower, r. p. m., and so on. He can watch this while he is doing the testing. If a default message comes up it will be given to the crew in a very simple fashion. The same with an electrical control problem. The shop man can call up by touching his key pad and finding out what the fault is, which system is in trouble, and what the nature of the disturbance is.

With one more password level he can then go into diagnostics, and it can ask him questions to verify operations step by step, measurement by measurement, where the true fault actually occurs. The fourth level is for locomotive signature. Right now the locomotive model, horsepower, current limit, power matching, and so on, are contained on separate modules and cards.

With these various levels now we hope to give the engine crew exactly what they have seen, the shop people what they need, and the staff people a lot more than they have seen before. We will store about the last 200 incidents in a rotating scroll type memory, so the knowledgeable man can pull out those displays and see them in time sequence so that he can see what the disturbances were.

MR. KESSENGER: Will these processors be a single type computer? How will we troubleshoot the processors themselves?

MR. SMITH: There are several different versions of the microprocessors in the locomotive. Overall they are working together to form the so-called computer.

The system goes through a self test procedure each time that control power is applied to the system. This takes about two seconds. If the self test does not pass, the faulty panel is identified in the display.

MR. KESSENGER: There are new versions of software available. Will it be a plug-in type or chip type or chip?

MR. SMITH: Yes to all three. We will have software we can change in the locomotive. Some are burned in and others are modules that will be changed out.

MR. KESSENGER: Right now the microprocessor is a diagnostic and history type device rather than a control device?

MR. SMITH: There are 10 microprocessors on the locomotive. They are all working together in a closed loop system.

MR. KESSENGER: Do they have a feedback to this diagnostic part?

MR. SMITH: Yes, they do.

MR. HARRY QUINN [Electro-Motive Division, LaGrange, Illinois]: You are going to find all this out Tuesday. [Laughter]

We have three microprocessors, 48K bytes ROM on each, operating in parallel. One microprocessor

backs up the other one to some extent. The two microprocessors are adequate for doing all of the logic and excitation functions on the locomotive. The two main operating processors do exactly what the locomotive is doing today.

As you well know, the 169 locomotive has been on the ICG for three months, and it is now on the Burlington Northern. It has both the standard super series excitation series on it as well as the microprocessor with a changeover switch. The primary purpose of this is to be sure the microprocessor is capable of giving us the same adhesion capability that the super series does with the analogue system we have today.

As far as diagnostics are concerned, we have three people in the Engineering Department who are from our Service Department and are writing the programs right now for the diagnostic routines. The display is an interactive display, where there are two buttons which give you the go-ahead to look for different things. You can instrument, and instead of bringing the instruments onboard the display will give you the option of selecting from 16 instruments the standard things you would normally look at in looking at the locomotive in the field.

As far as the crew is concerned, the only information the crew will get — and this is from feedback from railroads that have seen it — the man will get the same information he is getting today, and if he gets a hot engine he will know it is a hot engine. All the rest will be guarded so only authorized people like you will see it.

We are waiting to get the prototypes into your hands because we need your feedback as to how to handle this. There are many things we can do. The archive module which will be storing the history of the locomotive — and we have gone everywhere from bolting that into welding it in so it doesn't leave the locomotive — that retains the history of the locomotive.

There will be 1,000 failure events recorded in the archive module. You have to tell us how to put time on your railroad, because the Santa Fe runs from Chicago to Los Angeles; so you have to have some central location for time. We will give you time, date, the type of failure, what the throttle position was at time of failure, what the generator output was at the time of failure, assuming most of these will be traction motor failures. We will identify the motor which failed and what kind of motor failure.

I don't believe we can spend time on it at this meeting. I think every railroad in this room has been to EMD and has seen the display and the microprocessor system. As the CSX said, they will get the two microprocessor locomotives next year and there will be a total of 14 locomotives going out next year, and some in Canada, where we will then determine the target date to go into production in 1985. They will go into production as highly reliable locomotives, not as unreliable locomotives.

MR. KESSENGER: How does maintaining these compare with GE's as far as unit type repair or car repair is concerned?

MR. QUINN: We have feedback from our field people. The microprocessors are in three computer sections. You can pull a complete computer section out if you so desire and test it as an individual entity, or you can pull the individual cards. The CPU or the microprocessor itself requires enough sophisticated equipment so I doubt the railroads will want to invest in the repair of the CPU. It can be sent back to EMD and be repaired there.

The total program for the locomotive will be on what we call a Rompack, and all of the locomotive types, if you want to consider 6-axle, 4-axle, 12-cylinder, 16-cylinder, turbo, nonturbo—will be in the programs.

We have looked at all the customer extras you have asked for. They will all be put into the Rompack, and we think only those things you call for on your locomotive will be on a module called an EM module. That is a module that determines what you have ordered on that locomotive, and the characterization chips there will be identifying what is on the locomotive so that each microprocessor knows what it has and what it has to do.

MR. KESSENGER: Is it like the signature?

MR. QUINN: Yes. We call it characterization. There are a lot of new words to learn. The archive module is battery backed up at this time. We are not prepared to go to the railroads with the ultimate in the latest technology, but our long-range goal of course is to go to a permanent memory that does not require battery back-up. You can take the information off of the archive module if you want to put it in your main computers through an RS232 port.

We have to work with you on what type of equipment you have to take the information off that port so you can put it in your main frame computers. You can take the archive module out and take it to your main frame computer, or you can take the computer to the locomotive and take it off in that way. It will record such things as total kilowatt hours accumulated by the locomotive, total kilowatt hours accumulated by throttle position, so you can truly look at how you are utilizing the locomotive.

We will accumulate the distance the locomotive travels, or mileage, whatever you want to call it. That will all be part of the permanent record for the locomotive, so it is important to you that you keep the archive module with the locomotive.

That is something new for the railroads. You now have a device which is unique to that locomotive. You have the characterization module which is unique to the order. They can be interchanged between locomotives that have the same equipment on them.

You can call up the archive module through the interactive push buttons and look at the unit number that is stored in the archive model to be sure it is the unit number you have on the locomotive you are on. You can also set the clock, and you can then scroll the failure information that is recorded in there. We figure 1,000 events are enough. If you have 1,000 events on the locomotive you would throw it away anyhow. If you went beyond that point the oldest event would be dropped off.

MR. KESSENGER: Since you have this RS232 port on it, do you have a printer driver without taking it out of the locomotive, to get a hard copy?

MR. QUINN: We have to work with you on what kind of printer driver you want to drive. I am sure every railroad doesn't have the same thing. It would make our lives a lot easier.

MR. KESSENGER: In the future do you expect to see additional controls made with the microcomputer, like in the area of fuel with regard to pollution control or increased mileage? Will it ever replace the governor, or will it ever control the governor?

MR. QUINN: If you don't record it, yes. [Laughter] There is no question that the governor is dying. I don't see how, with that much computing capability on there, if you are familiar with computers — you have almost a main frame computer on every locomotive, and you can't continue to not use these capabilities on other functions. Our concern is that your demands are going to be moving faster than we can respond.

Obviously, you know, PROBE is out there. It amazes us that somebody would go into the engine with that level of detection, and down to the traction motors with that level of detection, because my good friend Darrell Walker is familiar with the lock wheel pick-up. We couldn't get the railroads to disconnect lock wheel pick-up before they dropped the traction motor, and with all that detection down on the support bearings we are leery about going into a lot of probes at this time. We have provision for them.

Some of you have seen our presentation. We have left room to expand so we can respond to your needs. We are also probing what kind of self programming you want. We can't let you get at the basic control circuits because then you would change the performance of the locomotive. When I listen to these stories about turbochargers, and know what we have to do in the control system to tune the control system to match the engine performance and everything else, and people randomly putting other turbochargers on, I don't know how you can do it.

The rate of loading all of those programs will be basic, and they will not be changed, but there are things you can do. Our friends on the KCS with their fuel saver system — there are some things on that system that do have value to them. One is, if you really want to control fuel then one way to do it is to control your trains. If you have a maximum speed limit on your railroad, then that could be programmed into the computer to the speed limit of your railroad. If you are running your coal trains at 40 mph and you don't want your crews running them at 50 mph, you can program in a speed limit for control.

Also, if you are putting power on the head end to get over the grades, obviously you are overpowered for the rest of the run. You could control the rate of acceleration on the locomotive to limit the rate at which the man can bring his train up to speed so that he is not using all the excess power you put on, just burning up fuel to get from one red block to another.

The obvious question is: Can you radio-communicate with the computer, and can you control the computer from your home office? Obviously you don't need a microprocessor to do it, but I am sure some of those things are going to come up as we go down the road and as both of us search together.

We have this powerful tool on the locomotive now. What are the best ways to use it to your advantage? Obviously it is there for your advantage, not for ours.

MR. KESSENGER: Is this piece of equipment manufactured by your company, or is it a standard bus structure? What type of CPU is it, and so on?

MR. QUINN: General Motors signed with Motorola, so we use the Motorola microprocessor system.

MR. KESSENGER: Would this be their standard CPU card?

MR. QUINN: It is not their standard CPU card. In the 20 years I have been in engineering I haven't been able to apply anything standard on a locomotive yet. If you men know of something, I would certainly like to try it. The CPU configuration, the bus structure configuration, the communication of the three computers to each other, is all our design.

MR. KESSENGER: Is it a 16 byte machine?

MR. QUINN: It is an 8 byte machine, three machines operating in parallel independent of each other, communicating with each other through common memory.

MR. KESSENGER: Are there any problems with scan time, like limitations in the 8 byte in the future if we control a lot of the functions of the locomotive?

MR. QUINN: As you expand the need, we definitely have in our program to book at 16 byte and even 32 byte processing. The thing you have to watch for when you start going to those levels of work transfer is, are they really viable on a locomotive? Those of you who are familiar with main frame computers know that periodically you lose a byte, you shut down, people don't get paid, or they get paid twice as much as they should. I am sure people in this room would not be too happy if we shut their locomotive down because we skipped a byte. I can't tell you how many bytes there are in this thing, but they have all got to go in series, and when you go home at night thinking about miles of bytes all lining up, you get nervous.

The system has been working very well. We have over a year of total logic control of the 169 locomotive, and the excitation response microprocessor has performed beyond our expectations. We see things in the microprocessor that we didn't expect. Our goal was to duplicate the analogue system, but we see the control of the microprocessor on the engine is much better.

MR. KESSENGER: How about noise? Outside interference?

MR. QUINN: The microprocessor doesn't make any noise.

MR. KESSENGER: I am talking about EMI.

MR. QUINN: I don't have all the answers on the EMI. We have not seen at this point anything we can directly associate with EMI as far as the microprocessor is concerned. We did have a failure, where a hand-held radio was held next to the microprocessor. We don't know if that was the case, but at this point we don't see any EMI problem. You know the microprocessor can be rolled out. It was out in the open position, and whether that did it or not we don't know.

MR. KESSENGER: How about the communication links from the sensors? Are there any adverse effects there?

MR. QUINN: Those are the ones you really worry about. As you know, the module compartment construction stays very much the same as it is today. The computers slide into the module compartment. They are held in the back with chips and two bolts in the front, so if you wanted to pull the entire computer out — and remember, there are three computers in there — the three computers can be pulled out as complete assemblies.

Remember, it is not like a computer you hold in your hand. It has its own power supply. It does what you want, and it operates the display. When you put a computer on the locomotive it has no more muscle than the thing you hold in your hand, so you have to have an interface there. You have to provide power output drivers to pick up the contactors. You have to have sensors to get the feedback from the other signals. You have to put all the analogue signals through an analogue to digital converter to make them digital, and then through the control.

You talked about 8 byte processing and the speed. We offload the computer for all mathematical functions. There is an arithmetic processor which does it much faster, and the computer picks up the results from that and then carries on. At this point we are not using high priority interrupts because we find no need for them. A complete loop of the total system and the excitation system of course is the one working the hardest. The logic system is just sitting there after it gets the engine started and gets you set up for whatever you are going to do.

Somebody asked, how do you know when a computer goes berserk? I'll tell you we spent more time trying to tell you what the name on that light would be to tell you the computer went berserk. I think we finally have it now, and I can't tell you what it is.

MR. KESSENGER: Where are you going to put the reset button?

MR. QUINN: Do you mean the re-boot? The re-boot for the computer —

MR. KESSENGER: It is behind the CPU. [Laughter]

MR. QUINN: There is an automatic re-boot in the program. It will re-boot up until the time the computer supervisor-policeman looks and says, "Hey, this thing is not working right," and turns on the red light. When the red light comes on, go to manual control.

MR. KESSENGER: Thank you very much.

Would GE like to say a few words about this microprocessor?

MR. SMITH: It almost sounds like Mr. Quinn and I have been riding the same locomotive. We have had the same sort of concept all the way through.

The microprocessor has a whole new time scale that you have to get used to. It used to take me half an hour to work out engine horsepower, and the computer does it now 20 times a second, which is kind of frightening. It calculates traction motor temperature every half-second. It reads all the input from the sensors 50 times a second, and it is still loafing.

We have had the same concern about interference with radio transmissions, and so on, and we are having the usual problems cropping up now on our testing on the Southern Pacific. Nothing has shut down the locomotive, but we do get false displays, and we are not sure who brought them with them. We are going through the usual growing pains of weeding out the deficiencies in shielding, and so on, but nothing so far seems unsolvable. We are running tunnel testing today on the Southern Pacific.

MR. STAROSCHAK: I would like to make a couple of comments and ask a few questions. Just one caution. The microprocessor is not AMP, so it behooves all the railroads to start having some expertise developed within their organizations to understand a little better the advantage of 8 byte over 16 byte or military standard microprocessor components versus in-

dustrial grade, and some of the details of that nature, so that the word "microprocessor" does not necessarily mean "good."

The airline industry and several others use something called redundancy, which is reduplication in either the control or diagnostic area. The concern is that if your diagnostics go belly-up in realizing all the improvements being made to prevent that, it can certainly happen. Diagnostics is an area where the craftsman is really going to revolve around it. I urge the manufacturers to give some serious consideration to making at least a diagnostic area redundant.

Usually what has to be done in that area is that you have to have a triple system. As I mentioned the other day, on the BART system they have three systems and one doesn't match with the other two, so the decision is that it is incorrect control, and it is taken off line. There is a warning signal that comes up, and at the next maintenance the part is changed out.

I would like to ask EMD why they feel the 16 byte is not the state of the art, whereas some have incorporated that very strongly. Secondly, why will you not be putting triple redundancy in some part of the control system, given the advantages in increased availability of the total system, even though there are some minimum additional costs and maybe some problems with increased volume in the additional components?

MR. KESSENGER: I think after we live a while with microcomputers we will be able to look at things like that.

Mr. Anderson, is GE planning anything for officers and employees of railroads regarding microcomputers?

MR. K. O. ANDERSON [Manager Customer Support, General Elecrtic Company, Erie, Pennsylvania]: Yes, Tom, we are continuing to develop new courses, as mentioned yesterday when we gave the talk on the new Training Center. We are already teaching our own employees about microcontrols and microcomputers. This is being developed, and as the locomotives with microcomputers are introduced we are getting ready for training the men. As a matter of fact, we will have our first pilot course for our own employees next month.

MR. KESSENGER: Do you have a name for it?

MR. ANDERSON: We haven't named it yet.

MR. KESSENGER: Do you have any literature like self-study literature available?

MR. ANDERSON: We will have it in the future, but not now. We will be training our own field service people, and a very limited number of railroad people by invitation later this year, and early next year, so it is coming. As the locomotives are introduced our training plans are being developed. It is kind of a race to keep training up with product development.

MR. KESSENGER: Does EMD have anything planned for use by the railroads in the future?

MR. WALTER WECK [EMD, LaGrange, Illinois]: You almost rode the same locomotive as Mr. Anderson. It is literally a race to stay ahead of the technology.

One of the gentlemen Mr. Quinn mentioned is over in the Engineering Department right now and is one of our instructors, and we are putting together the program as the locomotive goes together. We will have schooling available for in-house personnel and for our customers.

MR. D. W. CHIRIKOS [Manager Technical Section, EMD, LaGrange, Illinois]: I would like to supplement one item Harry Quinn brought up. He talked about prototypes going on next year with the microprocessor. All prototypes, except the two units for the Seaboard System which only have the microcomputer, will have the 710 engine onboard, which has an inch longer stroke engine and is going to be one of the subjects for Tony Chacon's New Developments Committee paper next year. EMD will cover the details on the mechanical changes and targets for fuel economy improvements within Tony's paper.

VOICE: My question concerns brush maintenance. I have had some information filter down to me that there are some unusual brush wear patterns in the same motor relating to common brush holders that might give the effect of a motor being spot-brushed and then running out of brush, creating a short brush damaged motor. Has anybody heard anything like that?

MR. KUZELA: I don't believe we have run into that situation on the Union Pacific. Maybe EMD could enlighten us, or one of the brush vendors.

MR. KESSENGER: Is this in regard to one specific motor or style of motor?

VOICE: It is related to the D77, and I believe the information came from the Missouri Pacific, but don't quote me on that.

MR. WALKER: I can't help you a lot, but we have had the problem on the Southern. See me later and I will give you the names of some people you can talk to.

MR. LEMONS: We did have some problems with the brushes on our GP38 locomotives, a new delivery at that time from EMD. There were approximately six traction motors that we inspected that had blown the brushes out of the three and nine o'clock brush holders, with the 12 and six o'clock holders with the original brushes still intact.

If this is what the gentleman is speaking of, we had only six motors in that fleet do this, and after we got the motors out and examined them there never was a decision as to what caused it. We have had no more failures since we removed the original brushes that were applied on this fleet of locomotives that we purchased.

MR. KESSENGER: Have any other railroads had any problems in regard to brushes?

MR. WESTERFIELD: We did see one D87 under our GP50s have the same type of failure. The three o'clock and nine o'clock brushes were totally destroyed and burned out; the six o'clock and 12 o'clock were intact. We use a different grade brush from the one Mr. Lemons uses, so I don't think we can blame the brush. To the best of my knowledge there has been no firm explanation as to what happened.

MR. KESSENGER: Are there any other questions from the floor in any area? Is there anything from last year in any of the technical reports that you have a question on? Gentlemen, this is the only time in the year that you have this opportunity, so don't go back home and say you wish you had asked a question. This is the time to do it. Your boss might read the paper and say, "Why didn't you ask?"

MR. DONALD MITCHELL [VIA Rail Canada, Inc., Moncton, New Brunswick, Canada]: Are there any mechanical inspectors here from other railroads who do what I call onboard audits or inspections on locomotives under full load when en route? If so, when they do these audits or inspections what type of hearing device do they use to nullify the noise in the engineroom, apart from ear plugs? Is anybody using a speaker type system with a boom and a headset?

MR. KESSENGER: Is this for vibration analysis, or what?

MR. MITCHELL: I would like to be able to record via a headset and a tape recorder everything that is functioning on the locomotive when running at speeds from 40 to 70 miles per hour.

MR. KESSENGER: Is there any railroad that can answer that? How about the Mechanical Equipment Committee?

MR. BROWN: There are ear protective devices available that our people use in the shops during load testing, and that type of thing. I believe this equipment is available for anybody riding locomotives if they choose to go inside the engineroom. They should wear protective ear equipment of some kind.

MR. WESTERFIELD: We are using disposable foam ear plugs. They are quite effective in reducing engine noise under those circumstances. They are very inexpensive and are comfortable to wear. During some static testing, where we have been involved in fuel testing, I have personally worn them for as long as five hours. Two hours is the most I can stand with the earmuff type.

MR. MITCHELL: Having used the ear plugs as indicated by Mr. Westerfield, I have found that they are not as adequate as the earmuff type that I am now using.

MR. KESSENGER: Are you actually communicating with someone else?

LMOA made some new friends while at GE's Learning Center, Erie, PA for its mid-winter committee meetings.

President Dick Holmes and Secretary Joe Koerner (far right in photo) were introduced to the "China Railway Locomotive Study Group" by General Electric Company's W. O. Lee, Sales Manager, China Project (center of photo).

Invitation was extended to the Chinese locomotive maintenance people to join LMOA, and their group leader, Mr. Zou, Chief of Division, Locomotive Bureau, Ministry of Railways (second from left) was presented a copy of the LMOA Annual Publication. Looking on is their interpreter, Mr. Xiong (far left).

MR. MITCHELL: No. I would like to be able to record defects via a tape recorder through a headset piece while en route.

MR. KESSENGER: That is a problem when people have to check engines under load and then communicate with the control booth. I know this is a real problem. We are also finding it now with some of the equipment in the shops that have computer controls, that we have data links with a remote location and we have to communicate, and there is a rather high noise level.

Maybe either our Shop Equipment Committee or our Diesel Mechanical Maintenance Committee might poll the different railroads in the coming year and come up with an answer for you. Maybe next year we will have a better answer.

Are there any further comments about onboard telimetry devices? That was a very interesting device. You don't have to rely on the crew to make diagnostic decisions for you.

If we have covered all the questions, I would like to turn the meeting back to Mr. Walker.

MR. WALKER: Thank you, Tom, and your Committee and all the participants for a job well done. Now that I know more than I wanted to about microcomputers, does anybody know anything about a retirement plan for a 45-year-old man? [Laughter]

I will turn the meeting back to our President, Mr. Holmes.

PRESIDENT HOLMES: Thank you, Darrell. Before closing, I have a few announcements.

The Railway Supply Association official annual luncheon will be held in this room at 12:30 p.m. today, and immediately following the luncheon the Executive Committee, committee chairmen and assistant chairmen will meet in Room 418.

Just a comment in regard to the acceptance speech I made, and my concern about the well-being of the LMOA and the hard work we are going to have to do now and in the future to get things working. I think the quality of the presentations this morning, and the stimulating discussion during What's Your Problem, indicates that the LMOA is indeed alive, well and kicking. So, may I call for a rising vote of thanks to this fine Committee.

[The audience arose and applauded.]

PRESIDENT HOLMES: The meeting is now adjourned sine die. We will meet again on September 24, 1984.

[The meeting adjourned sine die at 11:30 a.m.]

PRE-CONVENTION PRESENTATIONS

INDEX

LOCOMOTIVE MAINTENANCE OFFICERS ASSOCIATION

MONDAY, SEPTEMBER 24, 1984

TUESDAY, SEPTEMBER 25, 1984

WEDNESDAY, SEPTEMBER 26, 1984

ATTENTION EVERYONE COMING TO THE MEETING!

REGISTRATION FEE AT ANNUAL MEETING $10.00 PER MEMBER

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 view the exhibits, 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!

SPECIAL INSTRUCTIONS

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 1984 LMOA Membership Card for identification in registering.**

ALL RAILROAD MEMBERS! The ground rules of this Annual Meeting require:

"THAT ALL SUPPLY COMPANY HOSPITALITY SUITES MUST BE CLOSED TO AND OFF LIMITS TO ALL RAILROAD PERSONNEL WHILE THE MEETINGS ARE IN PROGRESS."

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.**

ALL SUPPLY COMPANY MEMBERS: Your strict observance of the above rule is absolutely necessary, will be greatly appreciated.

You are urged to attend the meetings because:

1. **Your** product might be discussed.
2. You might be in position to answer a question that is asked.
3. You need to know what **our** problems are, in some cases, they are **your** problems also.

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	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
1983	92	386	1025	1503

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Monday, September 24, 1984

10:00 A.M.

REPORT OF THE COMMITTEE ON NEW DEVELOPMENTS

Pre-Convention Presentation
Southern & Southwestern Railway Association

April 19, 1984
Holiday Inn (Gateway)
Huntington, WV

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Chicago & North Western Trans. Co.
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PERSONAL HISTORY
MAURICE B. CAMPBELL

A native Iowan. He attended public schools in West Des Moines, Iowa, graduating from high school in 1940.

He went to work for the Rock Island Railroad in April of 1941 as an electrician apprentice. Enlisted in the U. S. Navy in December 1942 and was discharged in December of 1945 as a first class aviation electrician's mate. His apprenticeship was completed in April of 1947. He was promoted to roundhouse foreman in 1958, and subsequently held positions as Diesel Supervisor, Electrical Engineer and Master Mechanic on the Rock Island. In October of 1980 he joined the Chicago and Northwestern as General Foreman at Des Moines, and in January of 1981 was promoted to System Shop Superintendent at Oelwein, Iowa, his present position.

He and his wife Rosalene have been married 41 years, have a son and a daughter, five grandchildren and three great grandchildren.

His primary hobby is playing golf and an occasional fishing trip.

I.
GE DASH 8 LOCOMOTIVES

A key objective in the design of the General Electric Dash 8 locomotive line is improved productivity. The simple equation

$$\text{Productivity} = \frac{\text{Reliability} + \text{Tractive Effort} + \text{Adhesion} + \text{Horsepower}}{\text{Fuel}}$$

exemplifies the relationship of the productivity factors. Any action which increases the factors in the numerator or improves fuel efficiency will increase locomotive productivity.

With five basic models as shown in Fig. 1, the Dash 8 retains a product structure that is quite similar to the Dash 7.

The traction horsepowers have been increased without significantly increasing the engine brake horsepowers. This productivity increase results from the careful management of the auxiliary loads.

As average auxiliary loads had been reduced up to 56% on the Dash 7, it was apparent that further reduction would require a major concept change. The Dash 8 microcomputer controlled AC fan and blower drives allow further management of the auxiliary load. When combined with a dynamic brake package and air compressor clutch, an average 4% fuel saving over 1982 Dash 7 design will result.

As the microcomputer is the key to many Dash 8 advances, an upfront review of the system is in order. Fig. 2 shows the location of the major elements.

The central computers consisting of the cab controller (CAB), auxiliary controller (AUX) and excitation controller (EXC) are located in the locomotive cab control compartment.

The cab controller, powered from an isolated DC supply, monitors trainline and operator input to

Dash 8 Models

MODEL	B23-8	B32-8	B39-8	C32-8	C39-8
ENGINE	12 CYL	12 CYL	16 CYL	12 CYL	16 CYL
BRAKE HP	2370	3250	4000	3250	4000
TRACTION HP	2300	3170	3910	3150	3890

FIG. 1

Computer and Electronic Control

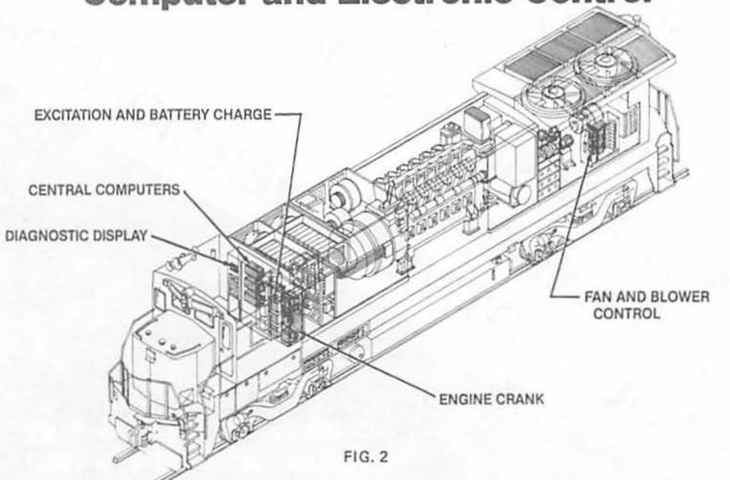

FIG. 2

provide supervisory control of the locomotive. Commands and data are transmitted on a serial communication line called the "brainline." The ability of the microprocessor to make logic decisions is used by the CAB to isolate faults. Many faults do not preclude safe locomotive operation but can be accommodated at the expense of more limited operation. The CAB controller receives all status information and then makes a logical decision as to the limits of possible operation. For example if the #2 traction motor blower should fail, CAB receives this status information, isolates the rear traction motor, prevents dynamic braking but allows the locomotives to continue on the forward traction motors. This action is entered into the diagnostic display for later use at a maintenance point. All these actions are done without intervention of the operator. CAB also provides onboard diagnostics and data outputs via a display panel located in the operator's cab.

The auxiliary controller (AUX) provides the control function for the radiator fan controller, equipment blowers, engine cranking and power contactors. AUX receives inputs from CAB as well as feedback from the sub-systems under its control. In addition, AUX monitors oil, water and ambient temperatures plus barometric pressure.

The excitation controller (EXC) provides the basic equipment control through the alternator field regulator, auxiliary alternator field regulator and battery charger. EXC also provides the administration functions for the contactors, relays and solenoids required for traction and dynamic braking effort of the locomotive. Microcomputer control has minimized the need for the multitude of relays which provided control logic in the past. In addition, a simple position indicator has eliminated the need for the many interlocks formerly used on power devices.

The equipment blower controller and radiator fan controller(s) are fundamental to the efficient management of the blower and fan loads. The controllers provide power conditioning (variable frequency and power) to operate the induction motors at partial and full speeds. The speed selected is dependent on commands received from AUX which monitors engine temperatures. The fan and blower controllers report their operating status back to AUX. The closed loop control is another advance made possible by microcomputer control.

Fig. 3 shows the location of the auxiliary equipment.

Each radiator fan motor has its own controller. AUX activates the fan motors as required on a step function—one at 25%, two at 25%, one at 50%, one at 25% etc. This system provides optimum control of engine temperature with maximized efficiency. The stepping function is also utilized as cooling requirements decrease. AUX balances loading on the fan motors by alternating which one is first on.

A total of three motor driven equipment blowers are applied. Due to the cooling requirements of its associated equipment, the speed of the alternator blower varies only as a function of engine speed. The two traction motor blowers share a common controller. They can operate at 25%, 50% or 100% speed depending on the cooling requirements of the motors in motoring or braking.

The AC auxiliary motors require an AC supply. The new alternator as shown in Fig. 4 consists of two separate AC machines in a common frame. Thus the designation GMG186 for four axle units and GMG187 for six axle units.

The main machine is the normal traction alternator providing power to the traction motors. The auxiliary machine has three separate windings. It provides isolated power for excitation, auxiliary motor supply and battery charging plus control system power.

The auxiliary alternator eliminates the need for the DC auxiliary machines and gear unit of the Dash 7. As these machines provide cranking on the Dash 7, an alternate method of cranking was required. Return to engine mounted cranking motors which had caused problems on early alternator equipped GE locomotives was not attractive. Dash 8 cranking is provided by making the main alternator perform as a synchronous motor. Under the direction of CAB and AUX, the engine cranking system provides an inverting function to power cranking. It operates from battery power and controls the power and frequency to accelerate the engine to firing speed.

The Dash 8 will incorporate an improved traction motor — the GE-752AG. Thermal analysis was utilized to reduce the difference between peak (hot spot) temperature and average temperature in both field and armature by 25%.

The field coil shown in Fig. 5 is an example of the study results. The field coil is now edge wound. Copper area was increased and Kapton insulation was introduced. The field coil is just one example of how manufacturing processes and insulating materials were modified to permit increases in copper sizes, eliminate asbestos, improve moisture resistance and reduce operating temperature.

The GE752AG motor provides improved productivity from increased tractive effort ratings. For example, the C39-8 has a continuous rating of 106,800 lbs @ 10.9 mph, a 10.2% increase over the 96,900 lb @ 11.0 mph of the C36-7.

Productivity is further improved by the elimination of a fixed power match system on Dash 8. On higher horsepower Dash 7 locomotives power match is applied to obtain compatibility with lower horsepower units. This operating benefit as shown in Fig. 6 often requires a significant reduction in 8th notch horsepower at tractive efforts higher than continuous.

Equipment Locations

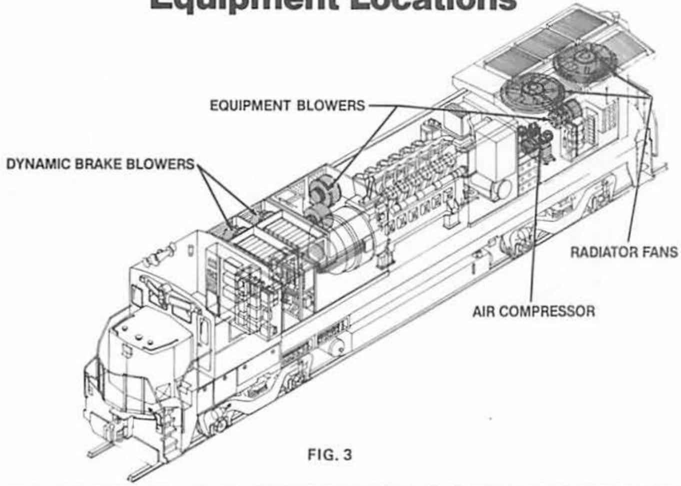

FIG. 3

Dash 8 Alternator

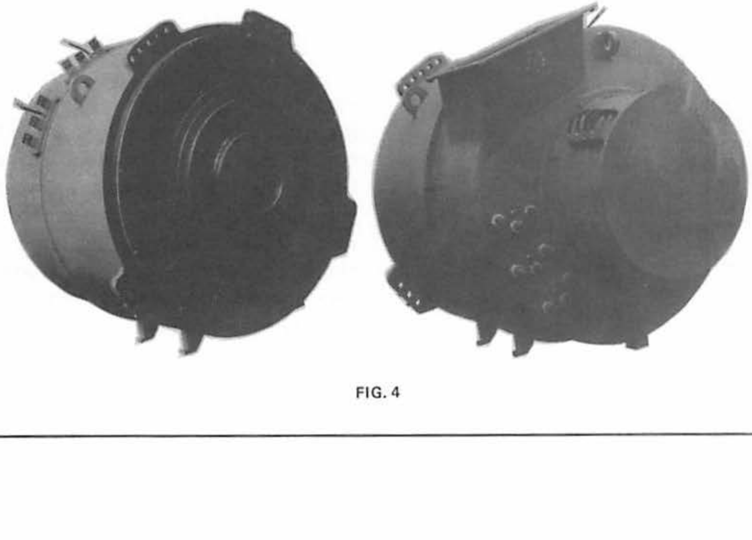

FIG. 4

GE-752 Motor Exciting Field Coil

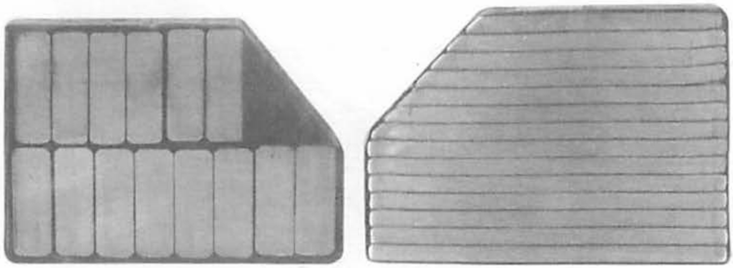

FIG. 5

Speed—Tractive Effort Curves

POWER MATCH ELIMINATED ON DASH 8 UNITS

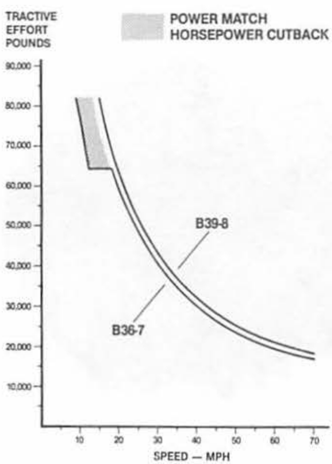

FIG. 6

Dash 8 has a motor temperature simulator feature in the micro-computer system. This digital model continually calculates motor temperature. It monitors all motors and is governed by the maximum temperature. The locomotive will provide full horsepower until pre-determined temperatures are reached. At that point, armature current will be gradually reduced, maintaining temperature until the continuous rating is reached. Under conditions of severe overloading, the locomotive can be caused to stall. The motors must then be cooled before re-applying power. The motor temperature simulator provides feedback for the control of the traction motor equipment blowers. In this manner, the blower load is efficiently managed and traction motors adequately ventilated.

It was mentioned previously that traction horsepower had been increased as high as 310 hp without a significant increase in engine brake horsepower. For example, the FDL 16 cylinder engine was applied in 1970 at 3940 brake horsepower with 3600 horsepower available for traction. On the Dash 8, the engine is applied at 4000 brake horsepower with 3910 horsepower input for traction.

In the intervening years, design improvements have been continually made to improve the reliability, efficiency and extend the maintenance intervals at this power level. Fig. 7 illustrates the progress in reliability.

The major improvements include:

Power Assembly
- Two piece steel crown piston
- Hardened iron liner
- Improved intake and exhaust valves
- Double O ring lower seal
- Improved upper seal
- Smooth piston pin

Bearings
- Grooveless main bearings
- Grooveless rod bearings
- Increased area thrust bearing

Turbocharger
- General Electric turbocharger
- Improved internal air seal

Fuel System
- 18mm double helix pumps
- Larger capacity parallel system
- Redesigned overspeed system

Engines incorporating these features have provided efficient reliable performance on the Dash 7 units. It is anticipated that similar results will be achieved on Dash 8 models.

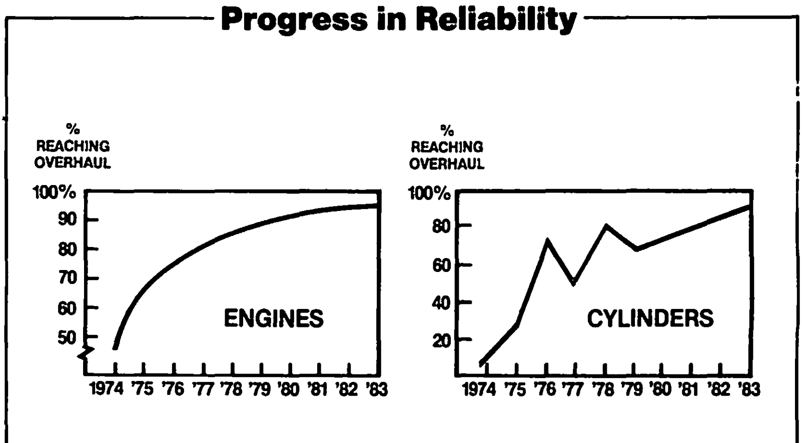

FIG. 7

The Dash 7 Sentry adhesion system will be incorporated into Dash 8. As the system has been computerized, it is now called Microsentry. The introduction of static excitation is expected to enhance overall performance by reducing the system time constants. Limited railroad operation supports this analysis but quantification will be made during adhesion tests which are to be conducted this year.

As previously mentioned, the Dash 8 dynamic braking grids are located in self contained dynamic brake package. This feature was introduced primarily as an improvement in fuel economy. When combined with the improved performance of the GE752AG, it is possible as shown in Fig. 8 to provide increased braking as an optional feature. On six axle units, peak braking can be increased 20% and maximum braking kilowatts increased 35%. A similar option is available on four axle units.

In the productivity equation, a broad meaning is applied to reliability. It includes maintainability and availability as well as component failures.

The on-board diagnostics and self-test will improve maintainability by pin-pointing trouble areas. Maintainability and availability are both improved by the replaceable unit (RU) concept.

To enhance the basic diagnostic value that the microcomputer system offers and to further reduce out-of-service time, all of the control equipment is packaged into RU's. These units as shown in Fig. 9 are designed for quick changeout. The diagnostic display spells out the specific RU that has failed. The maintainer loosens four bolts, breaks the connections and slides out the unit. Replacement is just as simple. This quick changeout is in the majority of cases the extent of troubleshooting and repair necessary before the locomotive can be self-tested and returned to service.

The introduction of microelectronics to the locomotive was a major milestone and raised several concerns — one of which was inherent reliability. Steps could and were taken to assure proper design and the use of the latest state-of-the-art manufacturing techniques and facilities.

To back-up the work on design and manufacture, a reliability assurance program has been instituted. This program, perhaps more accurately described as a reliability demonstration, is designed to assure that on-board electronics enhance reliability as well as improve productivity. The program includes the normal design reviews, vendor qualification, material tests failure analysis and process audits. The final step involves a comprehensive reliability demonstration.

The test will take about 2½ years and cost approximately $2 million. In full operations, four complete systems will function 24 hours a day seven days a week for over

Six Motor Dynamic Braking Curve

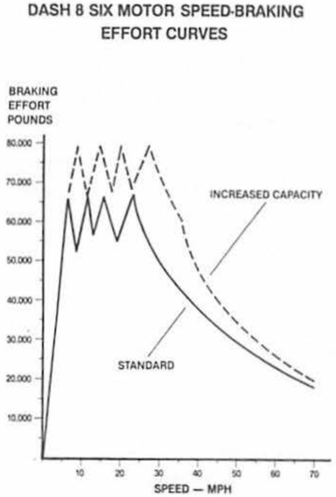

FIG. 8

Replaceable Units (RU)

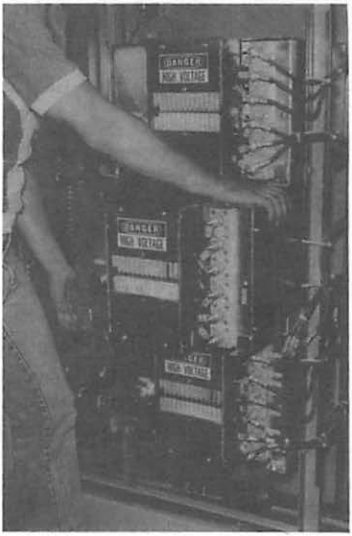

FIG. 9

Dash 8 Locomotive

FIG. 10

two years. Temperatures of minus 40 degrees F to 120 degrees F and severe vibrations are incorporated in the test program. The testing began in 1983 and will continue until the required reliability is demonstrated.

The Dash 8 program has successfully concluded the design and development stages. The engineering unit shown in Fig. 10 has been in operation since 1983. 1984 marks the start of in-service verification of the design advances. By the time of the September LMOA meeting, approximately 30 units will be in service. General Electric has been requested to present a program update at that time.

II.

EMD 50A LOCOMOTIVES

A number of prototypes of the successors to the 50 series locomotives, the SD50A and GP50A series, will be built and tested in the field during 1984 and early 1985.

The 50A series locomotives will feature EMD's new 710G turbocharged two-cycle diesel engine, microcomputer controls incorporating the Super Series wheel creep control system and improved D87A traction motors.

The 50A locomotives equipped with the 16-710G engine will be rated at 3800 horsepower for traction. These locomotives will have a significant improvement in fuel economy and efficiency, increased continuous tractive effort at full horsepower, reduced maintenance, and microprocessor diagnostics.

The 50A locomotives consist of two mainline models: the SD50A, a 6-axle locomotive weighing approximately 390,000 lbs. (176 900 kg.) and intended for heavy duty drag operation or medium speed freight trains in mainline service, and the GP50A model, a 4-axle locomotive weighing approximately 260,000 lbs. (117 935 kg.) and intended for intermediate and high speed service. (See Fig. 11).

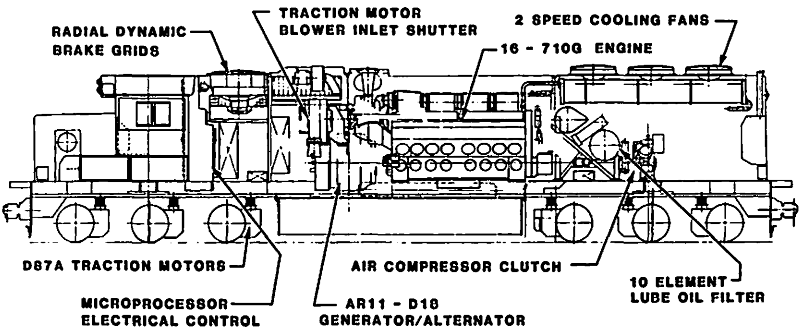

Fig. 11

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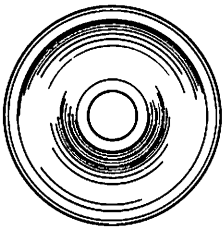
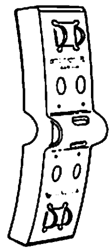


pressure poured wheels



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The SD50A retains a number of features introduced in the SD50 locomotive in 1980. These include a separate "radial" dynamic brake grid hatch with a compartment underneath for application of Locotrol equipment, and a "straight-thru" exhaust silencer. Also, a narrow hood over the engine compartment with hinged access doors on the top for accessibility and removal of the power assemblies from above with an overhead crane as well as through the side doors with the "C" hook fixture that is normally used for this maintenance.

In addition the SD50A incorporates a number of new or improved components that include the following:

- The new 16-710G diesel engine
- The AR11/D18 alternator with generator transition replaces the AR16/D18 alternator.
- New D87A traction motors
- Microcomputer controls replace the 50 Series module controls, 75% of the mechanical relays, and approximately 500 separate wires.
- Traction motor blower inlet shutters
- Air compressor clutch
- A new accessory rack equipped with a 10-element lube oil filter tank and a dual element fuel filter for increased capacity.
- A cooling system incorporating 3½ radiator cores per bank and 2-speed cooling fans.

The GP50A arrangement is patterned after the GP50 locomotive first introduced in 1980 but also incorporates new building blocks or improved components as noted on the SD50A with the following exceptions or modifications:

- An increased capacity AR17/-D18 main alternator replaces the AR15/D14 used on the GP50.

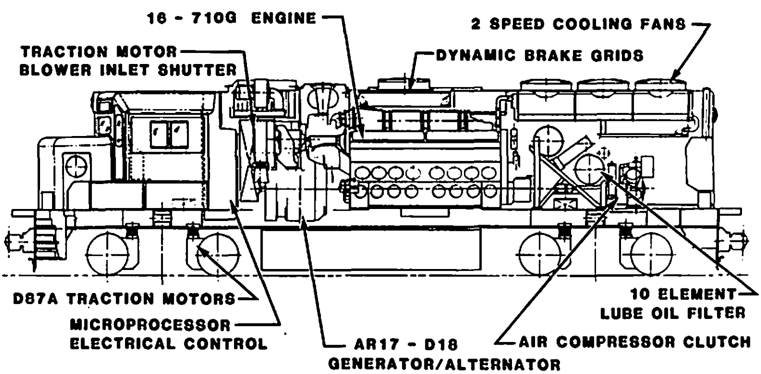


Fig. 12

— A modified cab and short hood arrangement with subtle aerodynamic modifications, a separate toilet compartment in the short hood, and a water cooler that is relocated in the cab compartment for easier accessibility by the crew.

The dynamic brake system on the GP50A is retained over the engine and uses the conventional box type grids with a single 48-inch diameter fan.

Locomotive Fuel Efficiency Improvements

EMD's engineering emphasis in recent years has been directed towards the development of more energy efficient diesel-electric locomotives even though this product is already considered efficient by most industry standards. The diesel engine has been a very efficient and reliable prime mover for locomotive applications; nevertheless locomotive builders have been challenged by increasing fuel costs to improve the efficiency of locomotives significantly at the same time other improvements in performance were being achieved.

Compared to the basic 50 series locomotives introduced in 1980, the SD50A and GP50A locomotives are 16.2% more fuel efficient.

The following is a list of features which contributes to the improvement in fuel economy.

— 16-cylinder 710G engine
— AR11 / D18 alternator, with generator transition on the SD50A
— 200 rpm idle speed
— Dynamic brake operation at 270 rpm (490 rpm with motor sensor regulation).
— Increased radiator capacity on the SD50A
— 2-speed cooling fans
— Lower traction motor air system resistance
— Improved "straight-thru" exhaust silencer
— Air compressor clutch
— Adjustable traction motor blower air inlet guide vanes.

The rating of the GP50A and SD50A is 3800 (3853 tcv) traction horsepower, reflecting a 300 (304 cv) horsepower increase achieved by a more efficient engine and a reduction in auxiliary horsepower.

The 710G engine design is based on its predecessor, the 645F, but uses a 9$\frac{1}{16}$" bore x 11' stroke (230mm x 279mm) and has a 16:1 compression ratio; is 1⅝" (41.3mm) higher and 4⅝" (117.5-mm) longer; the increase in length is due to the larger turbocharger. The 710G engine is rated at 3950 brake horsepower (4005 bcv) at 900 rpm.

In 1984 a number of these 710G engines will be produced and applied in locomotives for field evaluation following many years of development and durability testing in the laboratory at EMD.

The 710G engine features a number of improvements that provided increased fuel economy, increased reliability, and the potential for higher horsepower in the future. These features include the following:

— Model G turbocharger

— $\frac{9}{16}$" (14.3mm) diameter plunger injectors
— Larger diameter crankshaft
— Model G crankcase
— New camshaft.

The GP50A and SD50A will each incorporate a different AR type alternator to provide sufficient capacity to permit the traction motors to be connected in permanent parallel across its rectifier terminals, and also to provide high voltage capability for high speed operation without field weakening (shunting). The features of the AR alternators are as follows:

Ratings of Alternators

	GP50A	SD50A
Alternator	AR17	AR11
Continuous Current (Amps)	4680	8200
Max. Voltage (Volts)	1450	1300

Each machine is of the salient pole type with individual pole pieces and windings. All have 10 poles on the rotor and 90 stator slots. These machines use the same rotor and stator laminations and differ only in the total length of core and number of stator coil turns. Electrically, each alternator is actually two alternators with two complete and separate stator coils. In the AR17, the two alternators are permanently connected in series. In the AR11, the two machines are connected in parallel to provide the high current capability at stall, and automatically connected in series as locomotive speed increases to provide the high voltage required. The automatic switching is accomplished with a generator transition contactor. (Fig. 13)

In addition to improvements in the engine brake specific fuel consumption and main alternator efficiency, significant reductions have

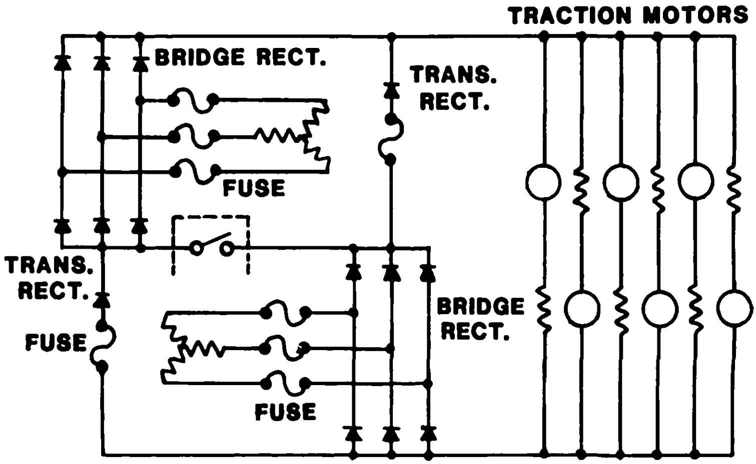


Fig. 13

been made in the locomotive auxiliary horsepower loads which result in greatly reduced locomotive fuel consumption. A number of improvements which were made on the 50 series locomotives have become a basic part of the 50A. Among these are:

- —200 rpm idle speed for reduced fuel consumption under idle conditions
- —Increased radiator core area for reduced cooling fan horsepower requirements
- —Two-speed radiator cooling fans with microprocessor control which provide five levels of cooling airflow
- —Revised traction motor air ducting for reduced blower horsepower
- —Straight-thru exhaust silencer for reduced exhaust back pressure (Fig. 14).

In addition to the above items, several new features will be incorporated in the 50A locomotives including:

- —Adjustable traction motor blower air inlet guide vanes which reduce traction motor cooling air and, in turn, blower horsepower during periods of low traction motor current and temperature (Fig. 15)
- —Two-speed dynamic brake with engine speed controlled for traction motor blower airflow by a traction motor temperature simulator
- —Air compressor clutch which disengages the compressor from the engine when the compressor is unloaded (Fig. 16).

The clutch is a spring-applied and air-released type which is a fail-safe design should the control signal to the clutch be interrupted.

Improved Performance Features

The D87A traction motor is the latest in a line of motors dating from the D7 motor introduced by EMD in 1938. This motor features a new high thermal conductivity Kapton (polyamide) armature coil insulation and an outer wrapper that has not been precreased to improve the heat dissipation from the coil. The transposed armature conductor that was released with the D87 motor will be retained to reduce the motor core losses. The D87A main field and interpole coils will continue to feature silicone rubber insulation that has proven very reliable in EMD railroad traction motors since its introduction in 1954.

To improve commutation a new four-brush brushholder is being introduced in place of the old three-brush brushholder. The new brush is made of three wafers and is thicker and narrower than the old style brush to prevent any problem with misapplication.

The 50A units are each equipped with a motor temperature simulator which monitors the temperature of the motors to allow maximum utilization of traction motor capabilities in the lower speed range. When the temperature of the motor is below a predetermined level, the controls permit full use-

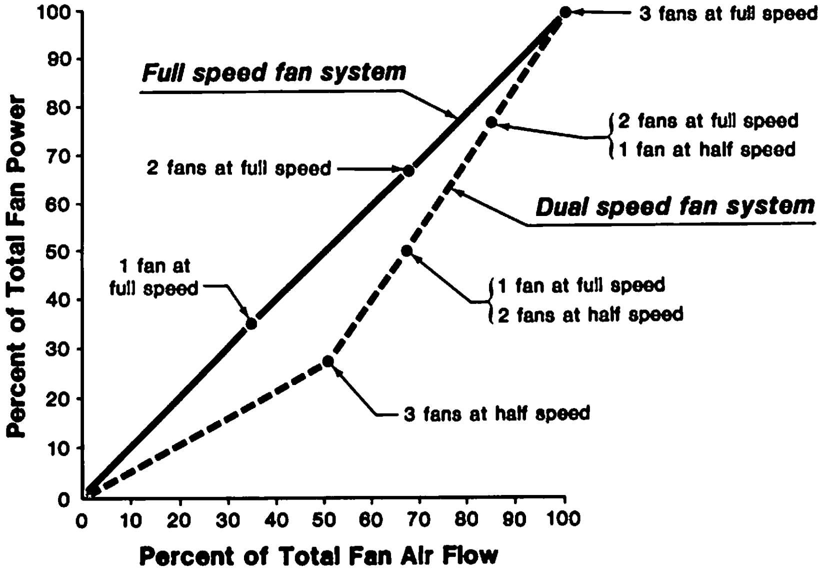

100
90
80
70
60
50
40
30
20
10
0
Percent of Total Fan Power
Full speed fan system
3 fans at full speed
2 fans at full speed
1 fan at half speed
2 fans at full speed
Dual speed fan system
1 fan at full speed
1 fan at full speed
2 fans at half speed
3 fans at half speed
0 10 20 30 40 50 60 70 80 90 100
Percent of Total Fan Air Flow

Fig. 14

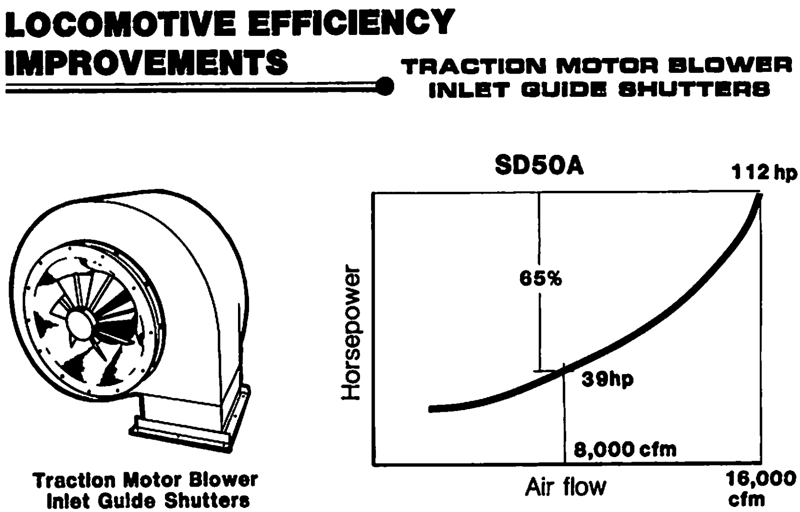

LOCOMOTIVE EFFICIENCY IMPROVEMENTS
TRACTION MOTOR BLOWER INLET GUIDE SHUTTERS
SD50A
112 hp
Horsepower
65%
39hp
8,000 cfm
Air flow
16,000 cfm
Traction Motor Blower Inlet Guide Shutters

Fig. 15

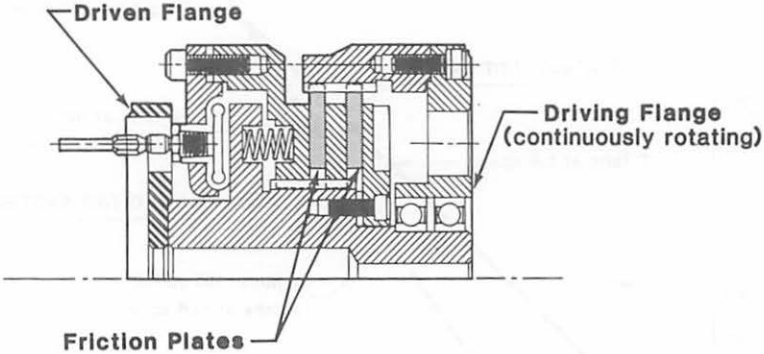


Fig. 16

able horsepower performance; for example, on the GP50A full horsepower performance will be available between 62,200 lbs. at 19.4 mph (277 kN at 31 kph) and 86,000 lbs. at 13 mph (382.5 kN at 21 kph). When the temperature of the motor simulator is above a predetermined level, the locomotive horsepower (the tractive effort) is reduced (Fig. 17A & 17B).

Two levels of optional dynamic braking are available on the 50A model locomotives — the standard braking effort vs. speed relationship as well as a special, high capacity braking system which provides 35% higher braking effort in the low speed range. Both systems with the extended range feature allow high braking efforts at lower speeds. It should be pointed out that, while the peak braking effort of the standard dynamic brake was maintained at about 10,000 lbs. (44.5 kN) per motor, for compatibility with 35, 40 and 50 series locomotives, at speeds above 27 mph (43.5 kph) the braking horsepower has been increased 17% over the 40 series. The 35% higher dynamic brake option provides 13,500 lbs. (60.1 kN) peak braking effort at 24 mph (38.7 kph). Special considerations should be given to the train, condition of the terrain, and number of motors in dynamic brake, when using locomotives equipped with this special dynamic brake application, in order to assure safe operation on curved track (Fig. 18A and 18B).

One of the most significant changes incorporated in the 50A locomotives will be the use of a microcomputer for all of the control system functions. It will also provide greatly improved diagnostics.

Three microprocessor systems are used supporting the logic, excitation and diagnostic functions using the mother board philosophy for interconnection within a subsystem. The design philosophy goals are:

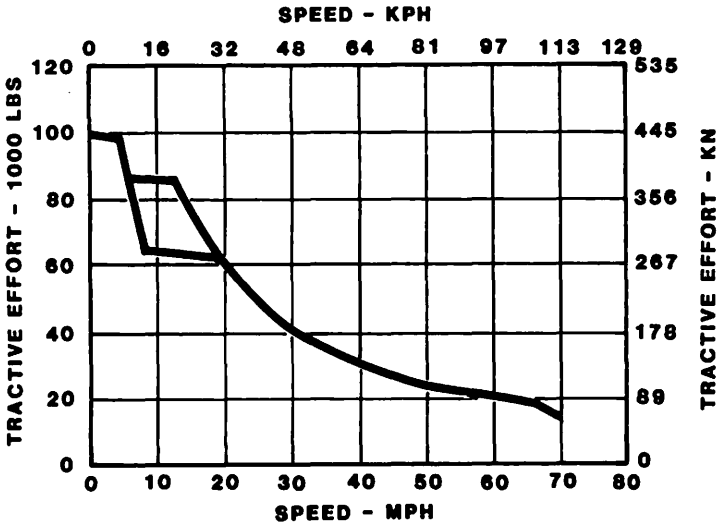


Fig. 17A

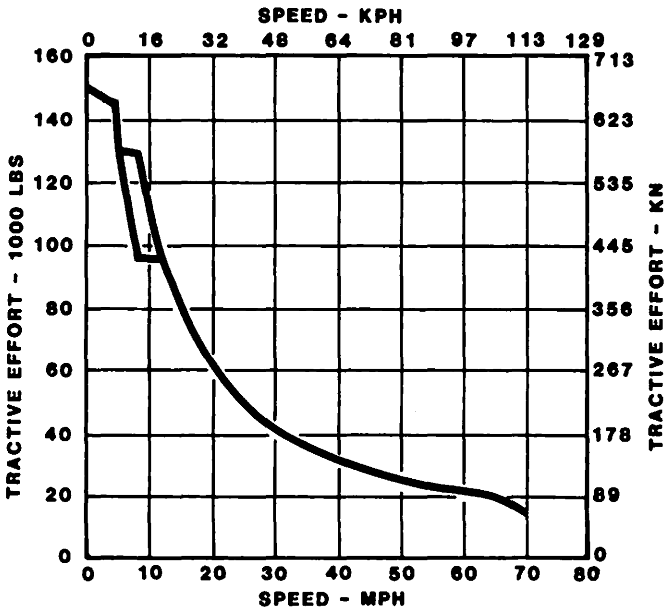


Fig. 17B

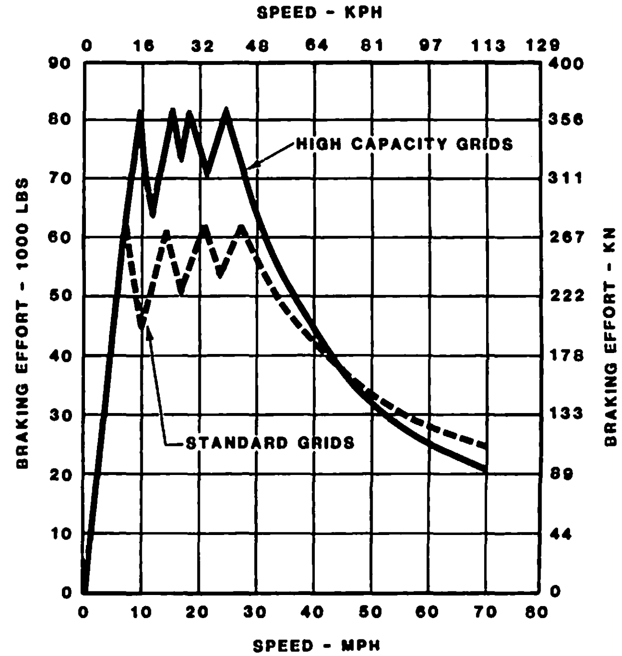


Fig. 18A

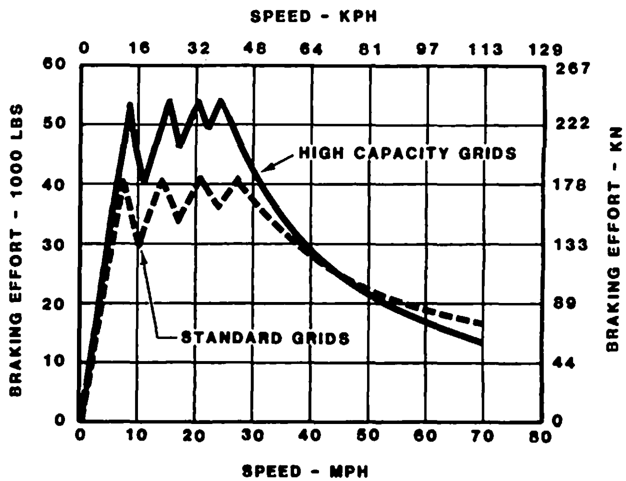


Fig. 18B

— Hardware standardization
— Ease of manufacturing
— Provide for as many customer options as possible in the basic system
— Redundancy
— User friendly
— Flexibility for the future
— Maximum reliability.

The advantage of this new system compared to the conventional controls are:

— Reduced use of relays
— Reduced cabinets wiring
— Programmable performance features
— Built-in diagnostic
— Automatic self-test capabilities
— Trip and parameter logging
— Enhanced performance.

System Configuration. When applied to the locomotive control system, the microprocessor will bring many changes to the control hardware. The lower portion of the high voltage cabinet will remain as it is today. Power contactors, the reverser, and motor-brake transfer switches will still be required for the high voltage, high current circuits. The circuit breaker and battery knife switch panel will also remain much the same (Fig. 19).

The module compartment and main control panel will change drastically when the microprocessor control system is used. With the exception of the voltage regulator and power supply modules, all the modules in the control system will be replaced with the computer. The computer eliminates the need for about 75 percent of the 40 to 50 relays typically used. The display panel will replace all the

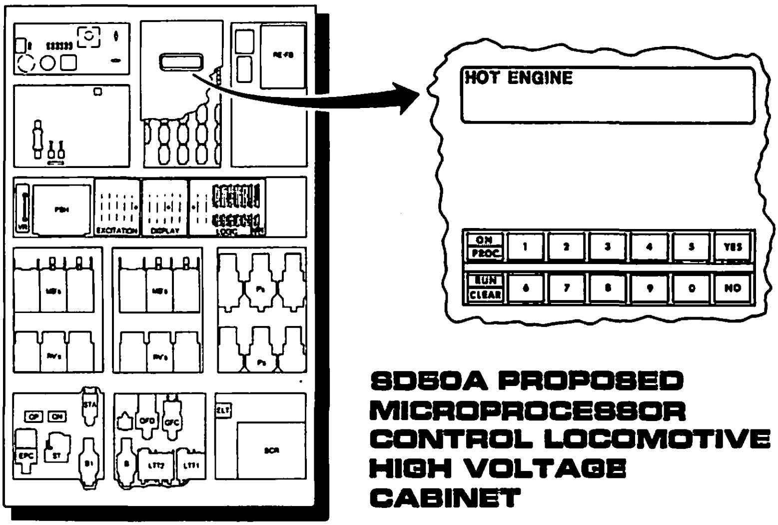


Fig. 19

indicator lights on the engine control panel, annunciator modules and other circuit modules. This display panel will be located on the center door of the main control cabinet.

The Logic Computer (L System) replaces the interface, protection and logic 50 Series control modules (SC, DG, DP, EL, GC, SA, and EP) as well as the relay logic system. All the locomotive control devices (throttle, reverser, dynamic brake, etc.,) provide inputs to the logic computer through the IOL input-output logic, modules. The computer responds by operating the proper devices (power contactors, switchgear, governor solenoids, etc.) and informs the second computer, the excitation computer, what level of traction power or dynamic braking has been selected by the locomotive engineer.

The Excitation Computer (E System) replaces the main power control modules used in the 50 Series control system (SE, FM, FG, LC, EN, CM, SW, TR, MS, RA, DR, and DP). This computer receives throttle and brake information from the logic system. Power or brake reference limits are established. Feedback information from the main generator, traction motors and dynamic brake system is provided to the excitation computer through the FBE, feedback excitation module, and converted to digital format. The computer compares the reference information to the feedback information to determine when and how power adjustments are to be made.

The Third Computer (D System) is devoted to the display and diagnostics functions. It replaces the present indicator lights on the engine control panel and circuit modules. This computer brings many new fault detecting and indicating features to the locomotive. The display and diagnostics functions will be presented in detail by the LMOA Electrical Committee.

Taking a closer look at the three CPU modules reveals some of the features of the microprocessor control system. Each of the CPU modules consists of a CPU module sub-assembly and a ROM pack which plugs into the CPU board. The ROM pack is a small circuit board which is initially equipped with unprogrammed ROM chips providing a total of 48k bytes of memory. The control program is then burned in the ROM pack. Without the ROM pack, the three CPU modules for logic, excitation and display will be identical. The CPU module takes on its unique identity when the ROM pack is installed.

The MEM module provides the identity for a particular combination of locomotive features. This identity information which includes such things as number of axles, engine horsepower and what options the customer has purchased for the locomotive, is stored in three additional ROM chips and is referred to as the characterization data.

When first powered up, the characterization data will be read by each of the three computers. This will tell the computers which portions of the program, stored in the ROM pack, apply to the particular locomotive. All programs pertaining to features which are not applied will be ignored.

Included in the standard software package are programs for all the standard features as well as some 65 extra features which are available as customer options. These would include such things as dynamic brakes, extended range dynamic brakes, automatic ground relay reset, etc. Only hardware such as the brake grids and contactors are added when the extra feature is specified. All of the required software is provided basically.

The excitation and logic computers perform all of the controlling functions on the locomotive, and includes "50 Series" control performance features, Super Series wheel creep control, and the latest fuel economy features.

Extended Maintenance Interval Features

To reduce locomotive out-of-service time for scheduled maintenance, a number of new features have been designed into the 50A locomotives including:

- —A new 10-element lube oil filter designed for a 91-day filter changeout interval
- —A two-element (or a single large element option) primary fuel filter, again for a 91-day filter changeout interval.

Both of the above features have been incorporated into a new equipment rack structure which is also used as the lateral support for the long hood, eliminating the need for the "X" bracing located between the compressor and the sandbox. Troublesome braze-at-assembly oil piping has also been eliminated and replaced by "O" ring equipped prefabricated sub-assemblies to help eliminate oil leaks in the equipment rack area.

In the truck area there have also been a number of improvements made to extend the maintenance interval such as:

- —An increased capacity axle support bearing cap with over 2½ times the usable oil capacity. In combination with the dual seal support bearing, a 91-day maintenance interval will be achieved in all but the most extreme cases (high speed combined with high ambient temperature)
- —An optional grease lubricated axle roller bearing with controlled axle lateral (rubber pads) which eliminates the need for periodic oil addition. The bearings are requalified at 250,000 miles or when wheels are changed out, whichever occurs first.
- —Plastic gear case seals to reduce the loss of grease from the gear case.

Two additional benefits are gained in the area of unscheduled

maintenance through the use of the microprocessor control system:

- Lower sand usage and longer wheel and rail life due to the Super Series adhesion system. Tests have shown that Super Series wheel creep control reduces sand usage to 25-30% of that used with the conventional wheel slip detection and control system
- Reduced troubleshooting and maintenance due to the diagnostic capabilities of the microprocessor.

A number of these 4-axle GP50A and 6-axle SD50A locomotives will be built and extensively tested by EMD in 1984; following testing by EMD the same units will be released to the railroads for evaluation of operating performance and reliability in the field before unlimited production in 1985-1986.

III.
NATURAL GAS LOCOMOTIVE

Northern States Power Co., Northern Natural Gas, Northern Natural Resources and the Burlington Northern Railroad signed an agreement to explore using natural gas as a locomotive fuel. Northern States Power Co. furnished a natural gas conversion kit fabricated by EMD which the Burlington Northern applied on a GP9 locomotive BN 1961, at its locomotive shop at West Burlington, Iowa.

Northern Natural Resources and Burlington Northern have jointly leased a natural gas tank-truck trailer which allows transporting compressed natural gas, placarded "flammable gas," by public highway. This trailer is being used as a temporary natural gas supply tank while static tests are being conducted at Northtown Yard in Minneapolis.

After completing the stationary tests, and after the TOFC gas car has been upgraded, the Burlington Northern is proposing to conduct over the road testing. The locomotive consist will include locomotive 1961, coupled directly to the temporary gas car. The locomotive will operate in local service on the Twin City region, and operations will be organized to obtain the greatest possible operating time in full throttle position at a speed no greater than 45 miles per hour.

Northern States Power Co. for several years successfully operated an EMD power car as an electrical substation, using compressed natural gas as its primary fuel. The unit developed 1500 horsepower, which met their requirements, but it is the same 16 cylinder EMD 567C engine used in the prototype GP9 1750 horsepower locomotive.

The design changes to burn natural gas are rather simple. Inside the engine cylinder, the piston crown is changed and consequently, the compression ratio is reduced. Under control of the governor gas valve, 40 psi natural gas travels through a 1½" common gas line running the length of each bank of the engine frame. Individual gas jumper lines provide natural gas to each cylinder at the test cock. Cylinder heads used on

the dual fuel engine have a gas inlet poppet valve in addition to the four exhaust valves. The valve is opened by a separate cam on the camshaft, acting through its rocker arm and push rod to depress the valve.

A light on the engineer's control stand lights whenever the gas valves are open. In addition to automatically controlling the gas flow by the governor or safety devices on the locomotive, the engineer can, if he desires, select to operate in dual-fuel or in the regular diesel fuel by the flip of a switch located above the light on the control stand.

The locomotive will operate on 100% diesel fuel when starting, idling, and when in throttle notches 1 through 4. It will automatically switch over to dual fuel operation when in throttle notches 5 and above. A time delay of 15 seconds will occur prior to change over to dual fuel operation. Whenever the throttle is moved from notch 5 to notch 4, the unit will instantly switch from dual fuel mode to 100% diesel operation.

The main gas shut-off valves are air operated from a main reservoir air line from the locomotive. There is one valve and one regulator on the natural gas car which drops the pressure in the main supply line from 2400 psi at the car to 100 psi as it comes onto the locomotive.

Manual valves have been installed in the main gas line aboard the locomotive so that the gas flow can be diverted through a gas flame sensor and measure the flow of gas through the system if desired.

Two of the air operated gas shut-off valves are located in the gas line on board the locomotive. These two valves and the air operated valve on the trailer will act to turn on the flow of natural gas whenever an air supply is furnished from the locomotive. This air supply can be shut off by flipping the switch or automatically if a failure to the locomotive's mechanical or electrical equipment occurs or if a break-into occurs between the gas car and the locomotive. The gas will also shut off if the pressure is low or high or if the pressure of the diesel pilot fuel supply drops below 10 psi. A gas leak detector is also mounted inside the engine room and if a gas leak occurs, the detector will shut off the air operated valves. Another shut-off valve is located at the engine overspeed trip lever and will close the gas lines in the event of an engine overspeed. The load regulator cabinet has been pressurized so that in the event of an unlikely gas leak, the gas cannot penetrate into the cabinet where an explosion might result if the load regulator commutator created any electrical arcing. There is also a temperature sensor electrically connected to the gas solenoid valve air supply control device which will shut off air to the main gas valves if abnormal temperatures are reached. If all of the safety systems are satisfied, gas will flow at 100 psi to another regulator which will reduce the pressure further to 40 psi as it enters the governor controlled gas valve which meters the volume of gas to be supplied to each engine cylinder according to the throttle notch setting.

In summary, the following events must occur before natural gas can flow:

1. The fuel selection switch on the control stand must be turned to the gas fuel mode.
2. The gas pressure must be within the specified limits.
3. The gas sensor must not detect a gas leak.
4. The diesel fuel pressure must be at least 10 psi.
5. An air supply must be distributed to the main gas valves from the locomotive main reservoir line.
6. The overspeed trip lever must be set.
7. The generator field control switch must be in the 'on' position.
8. The main generator and auxiliary generators must be producing current.
9. The control circuits must occur in the correct sequence.
10. The throttle must be in throttle 5 or above. Considerable stationary testing has been completed and the Burlington Northern hopes to begin road testing in the near future.

IV.

APPRAISAL OF THE AC TRACTION LOCOMOTIVE

1. Introduction

Profit margin: the bottom line. Ultimately our goal is to achieve optimum productivity of equipment and personnel. This implies minimal life cycle costs of machinery which encompasses normalized capital procurement, maintenance and operating costs over the expected life of the equipment.

For railroad Mechanical departments, locomotive component costs take a lion's share of their budgets. One of the largest locomotive component costs is the DC traction motor. Associated costs, such as brush changeouts, periodic commutator inspections, and lost availability due to motor failures additionally impact this expense.

Use of the rugged three-phase AC asynchronous (induction) motor in place of the DC commutator motor for traction applications has been suggested and actually used on numerous occasions in hope of drastically reducing DC propulsion system costs.

2. History

The three-phase asynchronous motor is one of the most simple electrical machines and offers in comparison to a commutator motor numerous advantages making it highly attractive for railway service. The continuing efforts to use the asynchronous motor as a traction motor are being made because of the extremely simple construction of this motor. In the case of the asynchronous motor, the current flowing within the rotor is not supplied through sliding contacts, but is produced in the rotor by induction. Therefore, only the bearings of the motor are subjected to wear.

The RPM of an asynchronous motor can be increased to values which are not possible for commutator motors, because they are not limited by a maximum commutator circumferential velocity. Compared with other traction motors used for alternating current drives, it should be mentioned that the asynchronous motor does not produce a pulsating torque but instead produces a uniform torque.

In the case of commutator motors, on the other hand, the current is supplied through sliding contacts between stationary brushes and the commutator which rotates. The entire commutation package occupies part of the very tight installation space of the tractive unit with the commutator subjected to the highest mechanical and electrical loads. It is one of the critical parts of the motor and requires continuous attention. At the same time, because of the limitations on the mechanical and electrical wear, the installable power is limited. It is for these reasons that a three-phase asynchronous motor can accommodate higher power levels, and thus higher tractive effort than a commutator motor of the same construction volume and the same weight.

Unfortunately these advantages are counteracted by an essential disadvantage: the speed of a three-phase asynchronous motor, especially in its most simple version as a squirrel-cage motor, cannot be varied in such a simple way as is the case with the commutator motor. Speed variation requires a power supply with which frequency and amplitude of the supply voltage can be varied independently over a wide range. Because of developments in the area of power electronics, however, today there exist means of eliminating this disadvantage and exploiting the advantages of the three-phase asynchronous motors.

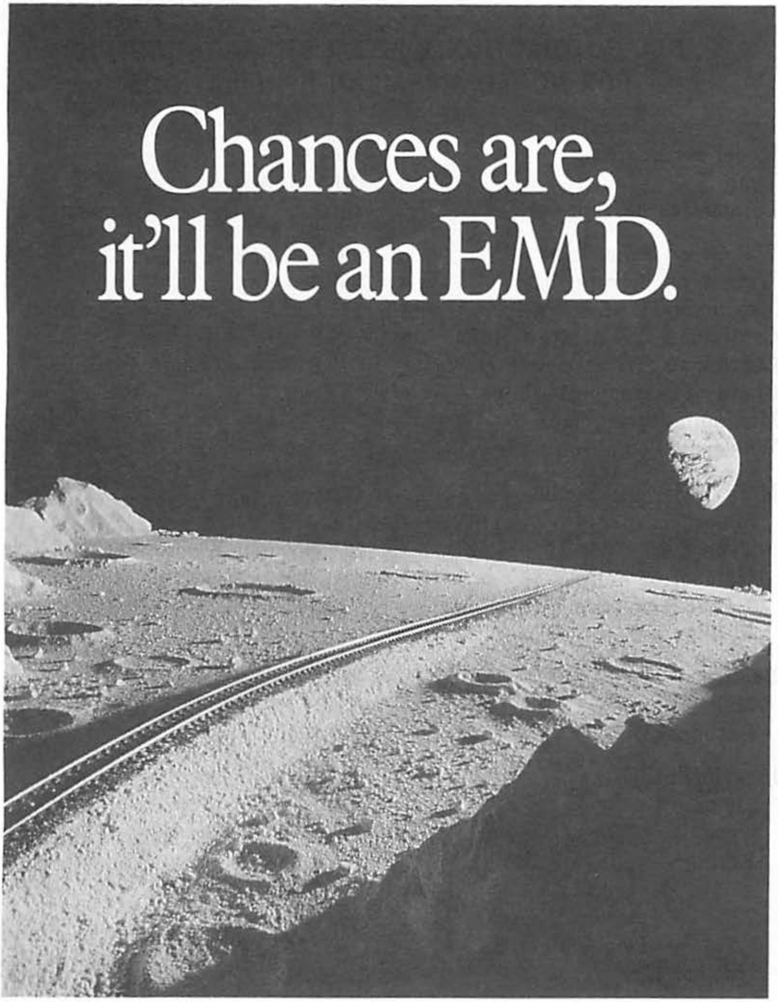
To date over 100 locomotives with AC traction packages have been produced in Europe. Over half of these locomotives have been diesel electric designs.

Most of these locomotives were produced by Brown Boveri and incorporate the PWM (pulse width modulation) control system using forced-commutated inverters.

Presently, in a joint venture between BBC Brown Boveri, Bombardier, the Canadian Pacific Railway, and the Canadian government, a 4,000 HP, 4-driven axle, AC traction, microprocessor-controlled locomotive is to be released for operational testing in 1984. Specifications for this locomotive are as shown on Fig. 20.

3. Electrical Background

The most widely used AC traction control/power system is that used by Brown Boveri, the pulse width modulation (PWM) system. In this system forced-commutated inverters are used to change a DC voltage into a three-phase voltage system with variable amplitude and frequency. They supply and control the traction motors (squirrel-cage motors). To obtain the


Chances are,
it'll be an EMD.

BBC 30 TRACTION SYSTEM CHARACTERISTICS FOR NORTH AMERICAN APPLICATIONS

Description	CP 4744 Project
Model designation	M640
Type	A1A-A1A
Locomotive horsepower	4000
Weight on rails, lb.	394,000 app.
Weight on drivers, lb.	263,000 app.
Maximum TE at start, lb.	117,000
Continuous TE at start, lb.	79,800
Continuous TE at power curve	72,840
Speed at power curve, mph	18
Maximum speed, mph	75
Wheel diameter, in.	42
Main generator model	GTA 9
Make	GE
Type	Synchronous
Number of Poles	12
Nominal voltage (DC)	1000
Rating, kW	—
Rectifier	30 full wave
Make	BBC
Rating, kW	3000
Inverter model	13SG07A
Make	BBC
Type	Voltage source, common motor bus
Rating — voltage (AC)	780
— current, A	715
— power, KVA	966
— freq. range, Hz	0-150
Number	4
Traction motor model	FRA 4073
Make	BBC
Type	30 Asynchronous brushless
Number of poles	6
Suspension	Roller bearing axle hung
Number	4

Description	CP 4744 Project
Gearing	
Ratio	79:16
Modulus, mm	10
Helix angle	4°
Controls	Microprocessor
Dynamic braking	
Rating, kW, at rail	2450
Maximum retarding force	Adjustable, up to continuous T. E.
Minimum speed for full braking force — mph	1.5
Self Load Test	Yes
Rating, percent of full engine power	100%

Fig. 20

required power ratings, inverters are operating in parallel. All motors are connected to a common three-phase bus-bar. In the braking mode the three-phase machines operate as generators; the braking power is dissipated in a dynamic brake resister.

Fig. 21 shows the basic circuit of the forced-commutated inverter. Each of the three-phase inverters shown in Fig. 22 consists of three equal electric circuits, the phase modules, which are connected in parallel to the positive or negative terminals of the DC voltage supply.

By triggering thyristors alternately, the positive or negative polarity of the DC voltage can be switched to the output. As a thyristor can only be switched on by a trigger impulse, but not switched off, additional devices are required to achieve forced commutation — the commutation thyristors, capacitors and reactors. Triggering and commutating occur in a very fast sequence and cover a range of some ten microseconds.

Control of the inverters is performed with the so-called subharmonic method. The duration during which the positive or negative polarity of the DC voltage is switched to the output is modulated to obtain the desired output voltage as a subharmonic of the higher rated pulse frequency; i.e., a slower sinusoidal AC signal. Current is smoothed by the motor's leakage inductance. The three phases are realized by phase-displaced triggering of the three phase modules.

4. Tractive Effort/Performance Characteristics

In the case of a tractive unit with three-phase motor traction, the tractive effort is controlled continuously and steplessly. In addition it is not possible for an individual set of wheels to slip significantly because a 2% increase in RPM causes the tractive effort of this wheelset to reduce to zero, according to the natural characteristics of the asynchronous motor (see Fig. 23). An individual set of wheels, therefore, will immediately be slowed down when a sudden deterioration in the adhesion occurs. The amount of tractive effort will be established by the level allowed by the adhesion value. The three-phase drive system therefore permits full exploitation of the adhesion value up to the maximum physically possible value without any risk of initiating the wheel slip.

In the case of a sudden reduction of the adhesion value of individual axles (e.g., arbitrary oiling of a wheel in the case of heavy starting) the maximum possible speed of this axle is determined by the fed-in frequency of 0.4 Hz for starting.

If, for instance, the adhesion value drops to approximately 12%, the axle can develop a speed of not more than approximately 0.4 km/h with this poor adhesion value since the speed is determined by the preset frequency of 0.4 Hz. The other axles, however, develop the full tractive effort. For this reason, it is not necessary to reduce the tractive effort of the other axles with a good adhesion value accordingly. In conventional systems this would mean a reduction of the tractive effort of the entire locomotive to an adhesion value of approximately 12% only because a single axle slips on an oiled track section.

For instance, in the case of a six-axle locomotive using the three-phase asynchronous motor drive system five axles will develop the full tractive effort corresponding to an adhesion value of 33% and only the axle on an oiled track section will participate in the development of the total tractive effort with a reduced adhesion value corresponding to approximately 15%. This behavior has been shown for starting. The same also applies, of course, to all the other speed ranges from zero to maximum speed.

However, if all axles lose their adhesion value at the same time, a very quick-acting electronic wheel slip control device takes over. This device is part of the electronic control and regulating device.

However, due to the natural characteristic of the asynchronous motor this additional electronic wheel slip control device for all axles comes into effect very rarely since slipping begins in most cases on one axle only. Such a slip is automatically stopped due to the natural characteristic of the asynchronous motor as described above. (See Fig. 24).

Traditional concern with traction motor damage due to power applied in stall condition or flashover occurring is minimized by design with the AC traction induction motor.

Full advantage of the tractive effort characteristic of the AC vs. DC system must be analyzed in light of a train operating philosophy, i.e., heavy drag, high speed, HP / ton dispatching, etc., since the short term ratings of the DC traction systems at low speed do exceed those of comparable AC systems.

5. **Advantages/Disadvantages**

As previously mentioned, reduced traction motor costs for AC traction motor systems are envisioned as the most significant cost saving. Additional tractive effort advantage exists as stall operation is possible for significant periods of time. Certainly the wheel slip control possible is excellent.

Disadvantages include requirement to maintain close wheel tolerance during wheel changeout as well as unknown additional maintenance costs associated with electronic power control system. Depending on dispatching techniques the exceptionally high short-term starting capabilities of the DC traction motor over any envisioned AC motor may also prove to be an AC disadvantage.

6. **Summary**

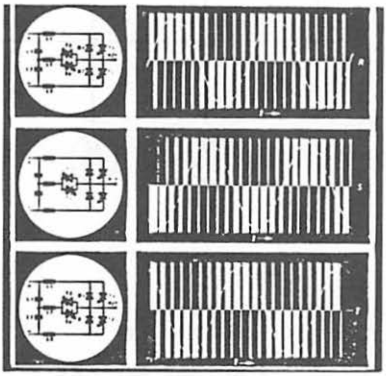
The AC traction system holds potential for reducing locomotive maintenance costs as well as increasing performance. Unknowns, however, do exist in the reliability of the electronic control system for this application. What the maintenance costs and reliability of the ancillary systems required to support the AC traction package are, must be determined prior to any final decision as to its overall cost effectiveness.

The overall value of a locomotive must be weighed in light of:

a. Its ability to pull and stop freight
b. Its reliability and maintainability
c. Its fuel efficiency.

For American heavy freight application, the second item, reliability and maintainability, has yet to be determined.

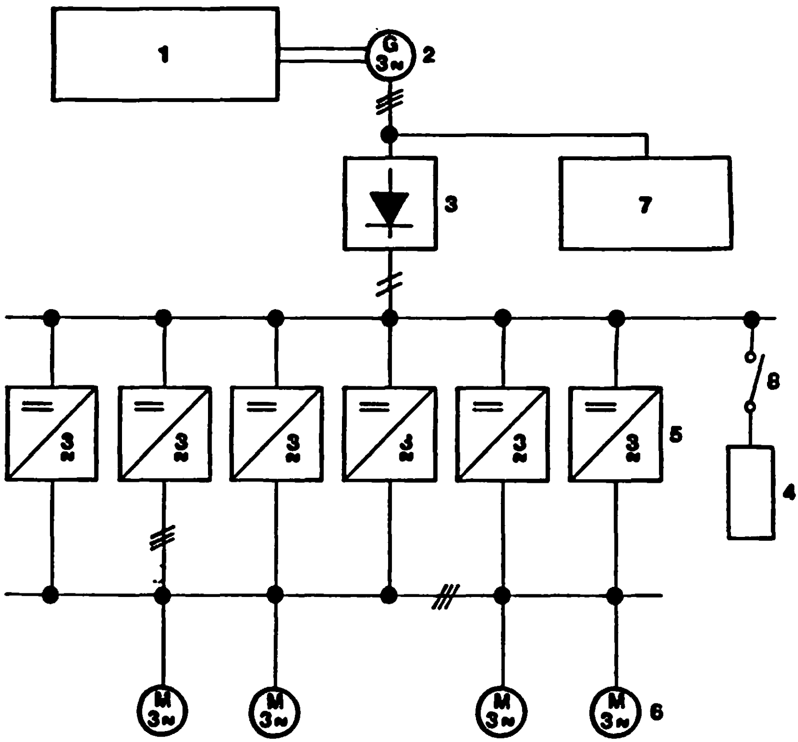
Any new product must first be a viable concept; secondly, must undergo prototype evaluation; and thirdly, must experience pre-production debugging prior to final production. It is with considerable anticipation that we look forward to the prototype evaluation of the Canadian CP 4744 locomotive.



Basic circuit diagram of three-phase inverter and subharmonic control method.

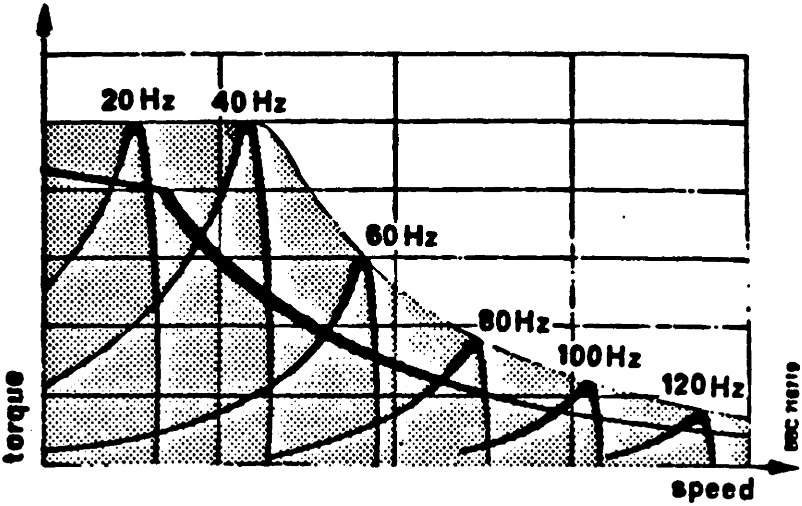
Fig. 21

MAIN CIRCUIT DIAGRAM



1. DIESEL
2. ALTERNATOR
3. RECTIFIER
4. BRAKING RESISTOR
5. INVERTER
6. TRACTION MOTOR
7. A.C. AUXILIARY
8. BRAKING RESISTOR CONTACTOR

Fig. 22



Torque-speed diagram for an asynchronous motor for operation with variable frequency. Desired traction curve superimposed.

Fig. 23

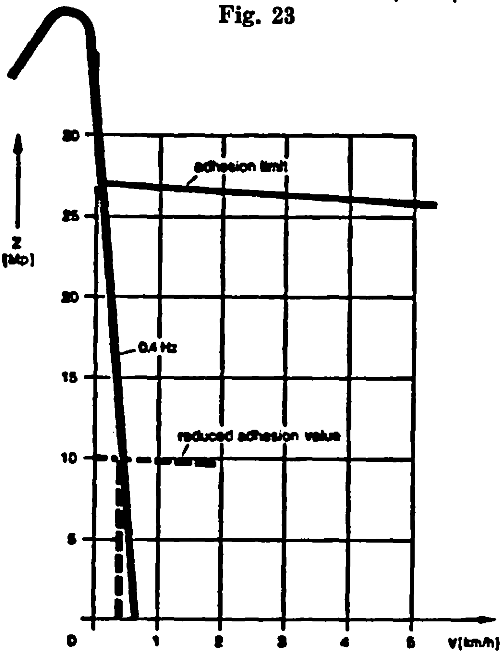


Fig. 24

LMOA wishes to express its thanks to Consolidated Rail Corporation for again hosting Pre-Convention Presentation at Altoona.

Our Fuel and Lubricants Committee's presentation was well received, in what we trust was a mutually beneficial experience.

Our thanks to Mr. J. V. Jolley, and his staff, for hosting our meeting and conducting a tour of their Altoona Shops.

Monday, September 24, 1984

1:30 P.M.

REPORT OF THE COMMITTEE ON FUEL AND LUBRICANTS

Pre-Convention Presentation: Altoona, PA

May 1, 1984
Holiday Inn
Altoona, PA

W. C. "Skip" HAMILTON, Chairman
Engineer of Tests
Seaboard System Railroad
Jacksonville, FL

VICE CHAIRMAN

K. A. Keller, Manager, Motive Power Performance, National Railroad Passenger Corporation, Washington, DC

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L. L. Willis	Asst. Mechanical Supervisor	NorfSou	Roanoke, VA

1984 TOPIC:
"IMPROVING THE BOTTOM LINE: WITH TECHNOLOGY"

PERSONAL HISTORY
W. C. "SKIP" HAMILTON

Born in St. Marys, Kentucky, on November 2, 1928. He attended St. Charles Elementary and High School located in St. Marys, Kentucky. He graduated in 1947 and began working for the L&N Railroad the same year. His railroad career began as an Agent-Telegrapher Trainee. Later that same year he transferred to Louisville, Kentucky, as a Lab Assistant, was promoted to analyst in 1951. He later attended Bellarmine College in Louisville.

He was promoted to Assistant Engineer of Tests for the L&N in 1968, and to Engineer of Tests in 1978. In 1980 he was appointed to Assistant Engineer of Tests for Seaboard System and still maintains that position. He has been a member of the L. M. O. A. Fuel and Lube Committee since 1978.

Mr. Hamilton is married to the former Mary Elizabeth Wiesemann and they have six daughters.

LOCOMOTIVE FILTERS

Proper filtration of diesel fuel, lubricating oil and engine air are essential for satisfactory operations of the locomotive diesel engine. Filters are designed to remove dirt and other contaminants that would cause excessive wear of engine parts or cause other operational problems. Although filters are relatively low in basic cost, improper maintenance or selection for a particular railroad environment can lead to shortened engine component life or costly engine shut downs and/or damage.

The engine builders have established certain basic mean pore size and service life recommendations for the various locomotive filters. Individual railroads because of their own unique operating conditions and service experience often modify these parameters. Locomotive filters are available both from the engine builders and from the filter manufacturers.

Fuel Filtration

Excessive quantities of fuel contaminants can seriously damage fuel system equipment such as injectors and pumps and/or reduce filter service life. These same contaminants can cause serious engine component wear. Fuel contaminants can be classified in two categories: soft and deformable, and hard. Soft contaminants include microorganisms, carbonaceous residues, waxes, and water. Hard contaminants include rust, scale, cracking catalyst fines, dirt and wear metals.

Fuel filtration should begin with wayside equipment. Current lower fuel inventory levels with shortened tank storage time significantly reduces settling time for contaminants. Lower tank levels can result in increased agitation of tank bottoms during filling. A program to regularly drain water condensation from tank bottoms is imperative. A recent survey of railroad wayside fuel filtration showed a wide range of mean pore size from two microns to 30 microns with changeout on either pressure differential of five to 40 psi and/or 30 to 90 days.

The following table outlines engine builders' recommendations for onboard fuel filtration and recent reported railroad practice:

Primary Filter	EMD	Railroad Practice
Size	6½" x 30"	------
Type	100% Cotton Fiber	------
Mean Pore Size	12-13 micron	5-25 micron
Service Life	90 days / 45,000 miles	30-92 days
Spin-On		
Size	2 - 4" x 7"	------
Type	Cotton Paper	------
Mean Pore Size	10-12 micron	7-28 micron
Service Life	90 days / 45,000 miles 30 days (switcher)	30-92 days

Primary Filter	GE		Railroad Practice
Size	6½" x 30"	or 9¾" x 30"	------
Type	Paper	Two Stage Paper	------
Mean Pore Size	13 micron	13-15 micron	5-30 micron
Service Life	30 days	90 days	30-92 days

Lubricating Oil Filtration

The primary purpose of lubricating oil filtration is to protect the engine from excessive wear by removing abrasive particles. Fuel contaminants and unfiltered airborne dirt can contribute to the generation of additional wear metal debris in the engine itself. Today's pleated paper lubricating oil filters must have fine enough mean pore size to effectively remove harmful abrasive particles and yet not plug prematurely from carbonaceous oil sludges. Other important design characteristics include type of paper fiber, resin type and saturation, ability of paper to withstand high oil temperature and pressure with limited deterioration, resistance to slight water contamination, paper strength, adequate paper surface area, effective end seals and bonding, and adequate center tube strength.

Present EMD lubricating oil filtration recommendations call for multiple 30 inch 12-13 micron mean pore size 100% cotton fiber paper elements with a two month/or 30,000 mile service life. Turbocharger filters are single 20 inch 20 micron mean pore size cotton paper elements, as are the single element $2\frac{31}{32}$ x $7\frac{7}{16}$ inch turbocharger soak back filters. These have the same recommended two month / 30,000 mile service life. EMD filtration system incorporates a lubricating oil filter bypass valve.

GE offers both a 30-day filter with a 22 micron mean pore size pleated paper element, and a 90-day filter made with a stronger paper and a more open mean pore

size of 31 microns. However, several railroads report they are unable to obtain the 90-day service life with this filter. The GE system is a full flow system with no filter by-pass valve.

Engine builders have filter recommendations which they believe are most suitable for their equipment. However, individual railroads have modified their lubricating oil filter practices to meet their individual local conditions and operating variables.

Air Filtration

Good air filtration is critical in protecting piston assemblies, turbochargers and related components from abrasive wear by particulates. One engine builder has reported the dramatic effects of inadequate air filtration with locomotives operating overseas in a severe desert environment. Six new SDL40-2 locomotives were placed in service in January, 1982, on an iron ore hauling line in the Sahara Desert in Mauritania. Within 10 months, or approximately 100,000 kilometers service, units were taken out of service because of severe piston ring wear and breakage, liner wear, continually rising silicon levels in the lube oil, and large amounts of 0-5 micron silicon dust in the oil, airbox and air filter housing. These units were returned to service in 1983 with new power assemblies and three types of specially designed ultra-high efficiency engine air filters and have been performing satisfactorily to date.

Although U. S. railroads do not encounter the continuous severe conditions noted above, this example vividly illustrates the prime-importance of good air filtration. Both engine builders' newer locomotives air systems incorporate primary inertial filters that deflect the air flow. Heavier particles are unable to negotiate the sharp turns and thus are carried to the end of the filters and discharged. This type of filter requires occasional cleaning as specified by the builder.

Both builders also supply as standard equipment disposable pleated paper secondary engine air filters. Housings accept 6 to 12 filters either 36 or 45 inches long, depending on locomotive model. EMD recommends pleated paper filter changeout as indicated by manometer pressure drop across filter. Railroad experience indicates a six to 12-month service life. Builders also will supply at customer request a modification to accept two to four fiberglass bag-type elements. Retrofit kits are available to convert from paper-type filters to the fiberglass bag-type filters. Several railroads have such programs underway because of the more positive seating and sealing of the bag-type filter, lighter weight, lower replacement cost, and fewer man-hours required for changeout. Recommended service life of the bag-type filter is three months, although it is desirable that the filter have sufficient dust holding capacity to protect the engine for an additional three

months in case of missed changeout. Some of the older locomotives in service use panel-type car body impingement filters. Changeout of these filters may vary from 30 to 90 days, depending on operating conditions.

For viscous impingement filters, important criteria include the density of the media (freedom from matting or layering that would prevent uniform penetration of adhesive in production, and penetration of dust in service), amount and type of filter adhesive, flammability (self-extinguishing when ignited by external source), and general good workmanship and construction. Important performance criteria for impingement-type locomotive filters include overall dust arrestance, pressure drop, and dust holding capacity under standardized test conditions.

Confusion exists today in variations of test conditions used by impingement filter manufacturers for rating their own and competitive filters. We believe the railroad industry would be greatly benefitted by a study and rewrite of the AAR Recommended Practice RP-559 "Standard Test Procedures for Unit or Panel Type Impingement Filters for Locomotives," adopted 1977.

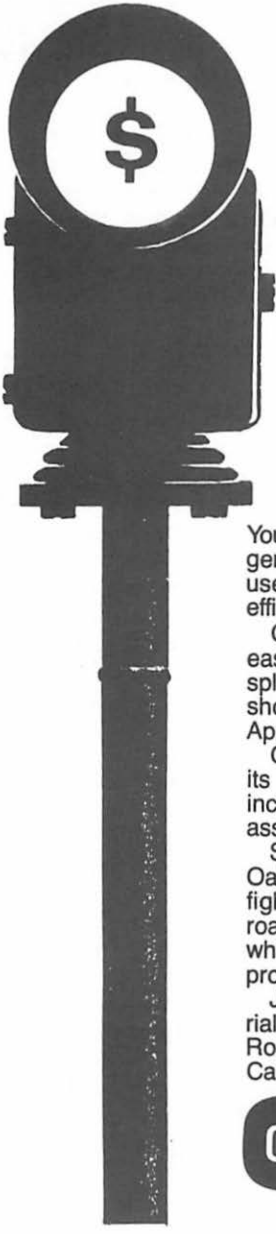
In closing, we emphasize the need for careful selection and maintenance of all locomotive filtration systems. Each railroad should study its filter programs in detail. The result will be longer parts life, increased equipment availability and optimum use of maintenance dollars spent for filtration.

Lube Oil Analysis—Data Systems

Spectrographic analysis of diesel lubricating oils lends itself readily to present state of the art data systems. This results from the spectrograph manufacturers designing their instruments with computer controls. In the early days discreet components mounted on printed circuit boards did what microprocessor chips do today. Today's microprocessor controls are about one-tenth the size they were twenty years ago.

In the past the data acquired from the spectrograph was printed out in hard copy form on ASR 33's or 35's and on punched tape. Today this information can be projected on CRT's, stored on magnetic tape or on discs. In addition this information is in a form that lends itself to transfer to large main frame computers for storage or computations.

As railroads acquired main frame computers for car control, accounting, purchasing and diesel locomotive control, many laboratories took advantage of this process to include lube oil analysis. What was once a laborious and time consuming task of transferring information about an engine's lube oil analysis to hard copy records now can be done in seconds. Also, file searches that took hours or days of searching through hard copy data now can be done in min-



utes. For example, if you wanted to know all the locomotives that have more than 30 ppm Silicon in them and have the answer classified by type of locomotive to determine if a particular type of locomotive has an air filter problem, you can have your answer in minutes. This is just one example of the many manipulations of data you can make with lube oil analysis data systems.

The remainder of this paper will show how some railroads have taken advantage of data systems in their lube oil analysis. Each road has tailored its system to its particular needs. For example, a railroad with one laboratory does not need to identify the laboratory that made the analysis whereas a railroad with three or four laboratories would include this in their data.

Railroad A

This road converted from hard copy records to computer storage in 1977. The original computer program has been modified periodically to update what it can do and to add various printouts.

Each road locomotive is sampled every ten days, i.e., locomotive 9537 would be sampled on the 7th, 17th, and 27th. Switch locomotives are sampled once a month. All locomotives are sampled at scheduled maintenance. All samples are sent to a central laboratory for analysis.

The samples are analyzed spectrographically on a Baird HA-5 with readout on a model 33 teletype. This gives a hard copy and a punched tape. The spectrographic data includes locomotive number, shop where sample was taken, sample date and ten elements. Simultaniously the viscosity is run and a blotter test is made. Any other tests that these data indicate need to be run are done subsequently. A tape is made of the viscosities and other pertinent data. These tapes are fed into a terminal connected by microwave to a main frame computer.

The computer compares the present sample to the last sample in storage. The computer is programmed for trend limits as well as maximum limits based on the crankcase capacity. If one or more of the elements exceeds the limits specified the data for that sample is printed out with the offending data underlined. Immediately below this it prints the last three analyses. The last six analyses are available if needed. Laboratory personnel then determine what corrective action should be taken if any. Diesel control is advised of the situation and determines to which shop the locomotive will go for corrective action. Laboratory personnel call that shop to apprise them of the situation. The corrective action called for is then entered into the data system in the form of a numbered code, i.e., 51-Fuel leaks, 52-Water leaks, 56-Iron wear, etc.

When the corrective action has been made, the shop reports that to the laboratory. This is entered into the data system under remarks, i.e., shop, date correction made and what was done. The data system is programmed to print out the next sample of that locomotive when received. Then laboratory personnel can determine if the corrective action taken did correct the situation or if further action is necessary.

Many safeguards have been programmed into the data system to keep incorrect data out. If this fails, data in the system can be edited to correct it. The locomotive number, shop identification, viscosity and all spectrographic data must be in "fields of four." Dates must be in "fields of two." If letters appear where numbers are expected or vice versa the data will not be accepted. Locomotive numbers must be real. Viscosities over 2000 will not be accepted.

Numerous reports are available from the data system. One is the recall of analysis data on one to six samples. Another is a pastdue report, i.e., a list of locomotives that have not been sampled in a specified number of days.

The analysis of air compressor oil samples is kept in this system along with the locomotive cooling water treatment analysis.

On a separate data system in the same mainframe computer is a report of the last fifteen defects whether they be mechanical or electrical. This information is accessed on a CRT terminal and includes defective lube oil analysis and the corrective action called for. These terminals are located at all shop offices and the laboratory.

Railroad B

Prior to December 1983

Data collection on all three spectrographs was handled by a model 33 or 35 teletype driven by the Baird Spectromet 1000 Digital PDP 8 computer.

The Baird software punched on paper tape, the day's date, the locomotive numbers, all element concentrations, and the operator inserted letter symbols indicating condemnable element concentrations. At the end of shift, the data on the paper tape was transmitted via microwave to the mainframe computer.

Available to a remote microwave terminal, was a report for each locomotive, which contained the four most recent lube oil spectrograph analyses. This terminal and these reports were not readily available to the lab technician when the current oil sample was being analyzed.

Once a month, the Information Systems Department produced the following reports:

1. A recap of all crankcase oil samples analyzed by the three laboratories.
2. A frequency distribution for each element concentration in each locomotive mechanical class.

December 1983

Information Systems Department replaced all the model 33 and 35

Railroad C

While the actual analysis of the lube oil sample has not been computerized the shop report of the results has been. This information is in the form of a computer printout indicating the oil condition as ok or, if defective, in the form of a coded corrective action to be taken.

TRACTION MOTOR GEAR LUBE FIELD TEST

In an effort to find a traction motor gear lube that would adequately protect pinions and ring gears operating with 900-horsepower traction motors (EMD GP 50's and GE B 36-7's), Santa Fe Railway conducted a head-to-head comparison of the gear lubricants recommended by the locomotive builders. Both locomotive builders and the two oil suppliers involved, participated in the test operation and the final inspection of the gears.

Test Configuration

At the inception of the test, three B 36-7's and two GP 50's were untrucked in the back shop for an unrelated problem. The 20 motor-wheel sets from these locomotives were reassembled with new builder-recommended, off-the-shelf pinions, ring gears, gear case seals, and gear cases.

Two brands of lubricant were placed in the gear cases in the following configuration:

* Number one truck on two B 36-7's and one GP 50 received EMD-recommended Lube E (Lithium Base Grease).
* Number two truck on the same locomotives received GE-recommended Lube G (Sodium Base Grease).
* Number one truck on one B 36-7 and one GP 50 received GE-recommended Lube G (Sodium Base Grease).
* Number two truck on the same locomotives received EMD-recommended Lube E (Lithium Base Grease).

Test Environment

The locomotives operated from May to September in unit coal train service between Northern New Mexico and Southern California. The train was dispatched with 2.3 horsepower per ton, was operated at 45 mph loaded, and 55 mph empty. Lube level inspection was at 4372-mile intervals, or about every 10 days.

At 40,000 miles into the test, the unit train was placed on an irregular schedule, making it difficult to keep the locomotives together for a common duty cycle and lube inspection period. Before placing the test locomotives into a different duty assignment, all gear cases were removed and pinions inspected. Three gears were removed from service because of condemnable scuffing, and two others were removed from service for non-test reasons.

Seventy-five percent of the test pinions were returned to their original positions, and gear cases were recharged with the same brand of lube.

The locomotives then operated from September to March in TOFC service from Kansas City to Southern California for an additional 60,000 miles. The trains were dispatched with 4.0 horsepower per ton and operated at 70 mph. Lube level inspection was at 10,000-mile increments, or every 15 to 20 days.

Physical Properties Of Used Lube Samples

* Based on infrared analysis, equal amounts of oxidation (more than a trace) were found in all high mileage samples.
* Based on inspections made during this test, there were no lube level differences which were attributable to ring gear rotation.
* Brookfield Apparent Viscosity Range At End Of Test (200° F.):
  Lube G (Sodium Base) —
    1,000 cP (No. 3 Spindle, 4 RPM) to 62,000 cP (No. 5 Spindle, 4 RPM)
    New: 1,100 cP (No. 3 Spindle, 4 RPM)
  Lube E (Lithium Base) —
    6,750 cP (No. 3 Spindle, 4 RPM) to 41,700 cP (No. 4 Spindle, 4 RPM)
    New: 7,500 cP (No. 3 Spindle, 4 RPM)
* Brookfield Apparent Viscosity Range At End Of Test (77° F., No. 7 Spindle, 4 RPM):
  Lube G (Sodium Base) —
    260,000 cP to 752,000 cP
    New: 334,000 cP
  Lube E (Lithium Base) —
    774,000 cP to Greater Than 1,000,000 cP
    New: 204,000 cP
* Lube Appearance At Inspection With 30° F. Ambient Temperature:
  Lube G (Sodium Base) —
    The ring gear teeth had a heavy coating of lube. It was necessary to wipe several times with an oily rag to inspect for gear tooth condition.
  Lube E (Lithium Base) —
    The ring gear teeth appeared dry and shiny, and tooth condition was readily visible. Close inspection revealed a thin, tacky coating of lube on the teeth. Different lube levels in the case did not affect this appearance.

Gear Lube Useage

* Gear Lube Useage — Average Per Case, In Unit Train, High Ambient Temperature 0 to 40,000 Miles Service (May to September).

	Pounds Per 1,000 Miles EMD	Pounds Per 1,000 Miles GE
Lube G	0.27	0.97
Lube E	1.01	1.18

* Gear Lube Useage — 40,000 - 100,000 Miles Average Per Case, In TOFC Train, Low Ambient Temperature Service (September to March)

	Pounds Per 1,000 Miles EMD	Pounds Per 1,000 Miles GE
Lube G	0.20	0.38
Lube E	0.49	0.38

Summary

In medium speed, heavy tonnage, high ambient temperature service, 70% of the 900-horsepower pinion gears lubricated by Lube E, and

30% of similar gears lubricated by Lube G, had varying amounts of scuffing and/or pitch line pitting. Distressed gear teeth were found on both manufacturers' gears, and with both brands of lubes. Matching distress was found to a lesser extent on all ring gears.

In high speed, low tonnage, low ambient temperature service, 100% of the 900-horsepower pinion gears lubricated by Lube E, and 56% of similar gears lubricated by Lube G, had varying amounts of tooth scuffing and/or pitch line pitting. Distressed gear teeth were found on both manufacturers' gears operating with Lube G. Matching distress was found to a lesser extent on all ring gears.

Results of this test suggest that the use of Lube G in place of Lube E will reduce the amount of tooth distress, but will not provide 100% protection.

Since this test, the manufacturer of Lube E has reported that compounding changes made to their product have improved its performance. At the time of this writing, no field test results have been published to prove or disprove this claim.

Experimental Lube T Test

Since neither Lube E, nor Lube G would provide 100% protection to the 900-horsepower gear sets, Santa Fe reviewed the physical properties of several other gear lubricants. Lube T (Lithium) appeared to offer improved performance over the first two lubes tested.

Physical property highlights of the three lubricants are as follows:

	Lube E	Lube G	Test Lube T
Soap Type	Lithium	Sodium	Lithium
Brookfield Viscosity 200° F. (A)	7,500	1,100	7,500
Brookfield Viscosity 77° F. (B)	204,000	334,000	398,000
Viscosity Base Oil SUS/210° F.	1,000	1,600	1,800
EP Anti-Wear Additive Type	Lead/Sulfur	None	Sulfur/Phos.

(A) No 3 Spindle, 4 RPM
(B) No. 7 Spindle, 4 RPM

Test Configuration

All test motor-wheel sets were equipped with new builder-recommended, off-the-shelf pinions, ring gears, and gear case seals. Both locomotive builders and the supplier of Lube T participated in the test operation and the final inspection of gears.

The lubricant was placed in the gear cases in the following configuration:

* Two GP 50's each had Lube T in three cases, and Lube E in one case.
* Two B 36-7's each had Lube T in three cases, and Lube G in one case.
* All make-up was Lube T.

Test Environment

The locomotives were operated from May to October in TOFC service from Kansas City to Southern California. Trains were dispatched with 4.0 horsepower per ton and operated at 70 mph. Lube level inspection frequency was at 10,000-mile intervals, or about every 21 days.

Physical Properties of Used Lube T Samples

* Based on infrared analysis, no evidence of oxidation was found in the high mileage samples.
* Brookfield Apparent Viscosity of End-Of-Test Samples (200° F., No. 3 Spindle, 4 RPM):
  1,000 cP to 2,500 cP
  (New: 7,500 cP)
* Brookfield Apparent Viscosity of End-Of-Test Samples (77° F., No. 7 Spindle, 4 RPM):
  150,000 cP to 500,000 cP
  (New: 398,000 cP)
* Lube Appearance At Inspection With 70° F. Ambient Temperature:

  Ring gear teeth had a heavy coating of lube, and it was necessary to wipe several times with an oily rag to inspect for surface condition.

Compatibility Observation

Realizing that the observation of lube performance in two gear cases does not provide a high level of confidence, this test suggests that introduction of lithium-thickened lube make-up into gear cases containing sodium-thickened lube does not create an undesirable viscosity reduction. The user should be advised that this observation is for Lube G and Lube T only. Additional testing must be done to determine values of viscosity change for other combinations of lube.

Test Results

* After 95,000 miles, a gear case tear-down inspection found 11 out of 12 (92%) of the ring gears and pinions operating on Lube T for the entire test had no tooth distress or measurable tooth profile wear.
* The condition of the gears which operated on Lube E and Lube G, with Lube T make-up, was similar to conditions found at the end of the original test.

Synthetic Lubricants

This committee is charged with keeping abreast of new developments in lubricants of interest to the railroad industry, as well as reporting current practices and developments.

In previous reports, we have commented on the possible use of synthetic base diesel engine oil for locomotives. Because oil change-outs were often related to reasons other than lubricant failure, i.e., water leaks, fuel dilution, the cost of such engine oil (3 to 5 times as much as conventional oils) precluded further consideration.

Today, we know that synthetic based lubricants with synthetic hydrocarbons (SHC) as the base are marketed for numerous applications in hydraulic controls, bearings, gears and internal combustion engines.

In hydraulic systems used in atmospheres such as in mining, the steel industry and aviation, synthetic fluids have become standard. This helps to prevent ignition by exterior sources of heat, preventing disastrous fires.

Attention has been focused on synthetic lubricants since synthetic or synthesized-base automotive engine oils were introduced into the retail market. A review of the history and a description of their manufacture will help us as maintenance officers to decide whether they have applications in our areas of responsibility.

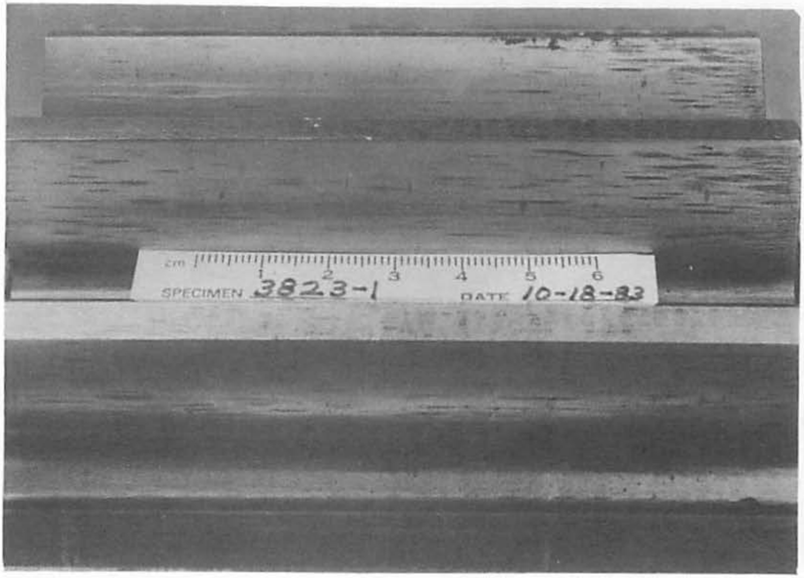
More than 40 years ago, organic esters were formulated as aviation gas turbine lubricants, polyglycols for automative brake systems, and phosphate esters for fire-resistant hydraulic fluids. They are important because they provide an alternative under severe conditions where the performance of even the best mineral oils is marginal.

Some of the attributes cited by manufacturers of synthetic oils are:

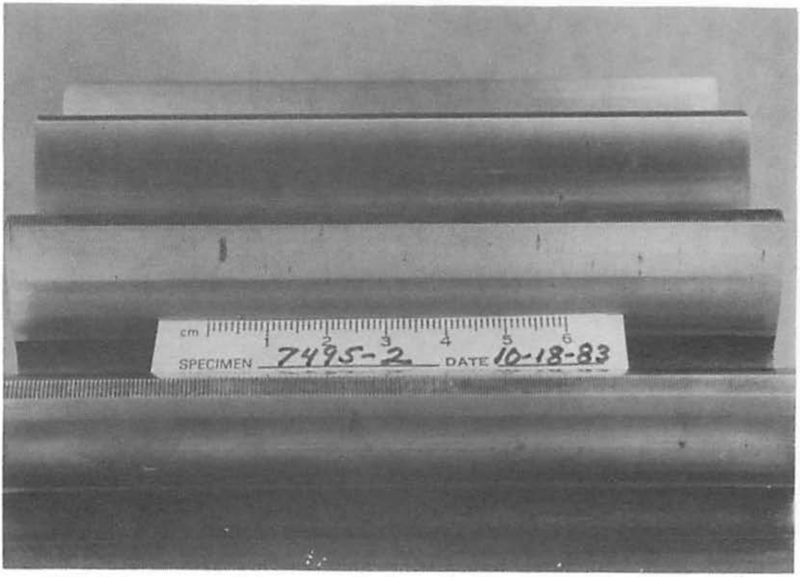
1. High temperature stability
2. Long life
3. Low temperature fluidity
4. High viscosity index
5. Improved wear protection
6. Low volatility
7. Non-waxing

Some disadvantages are

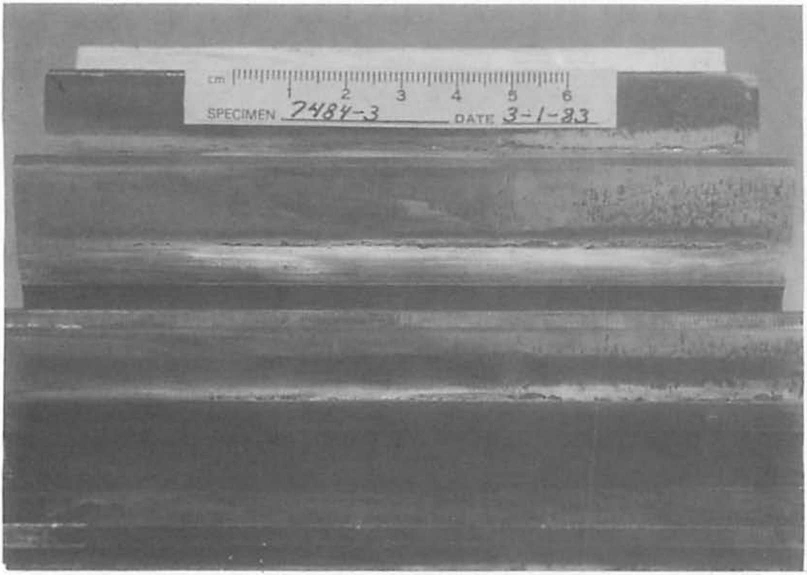
1. Higher cost than mineral based oils



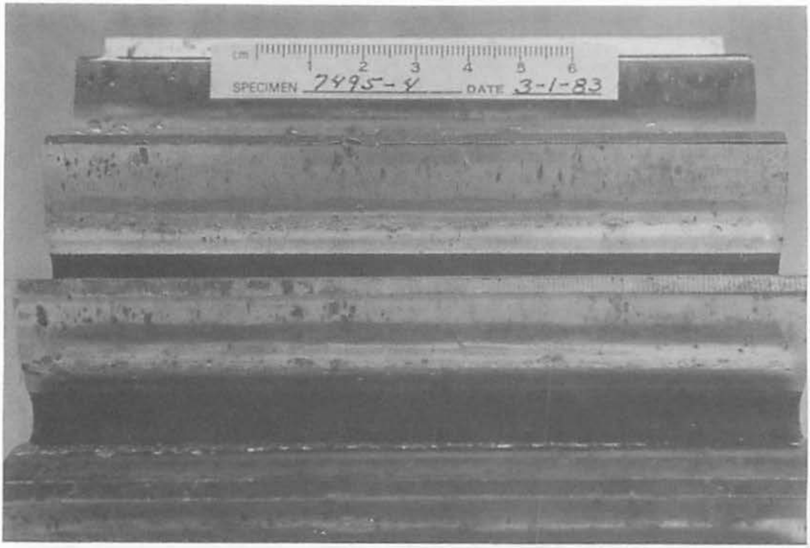
EMD pinion gear with no tooth distress after 100,000 miles. Horizontal lines are tool marks resulting from gear manufacture.



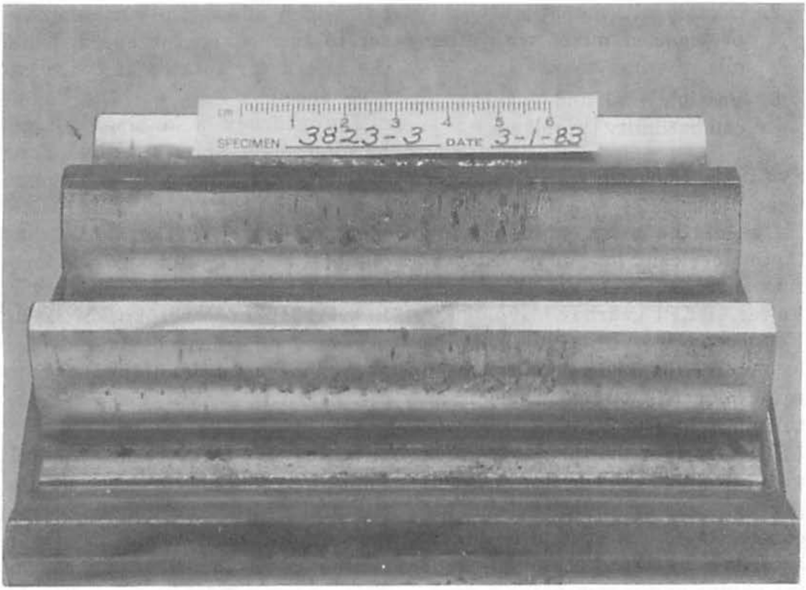
GE pinion gear with no tooth distress after 100,000 miles service.



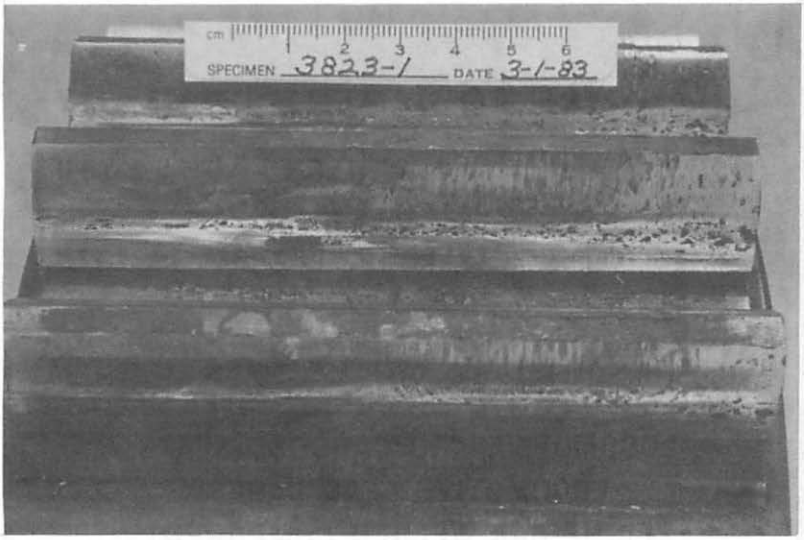
GE pinion gear with pitch line pitting and scuffing after 100,000 miles service.



GE pinion gear with pitch line pitting and scuffing after 100,000 miles service.



EMD pinion gear with scuffing after 100,000 miles service.



EMD pinion gear with pitch line pitting and scuffing after 100,000 miles service.

2. Occasional compatibility problems if mixed with other oils
3. Possible seal and gasket compatibility problems.

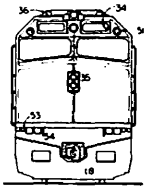
Synthetic Lubricants in Gear Boxes

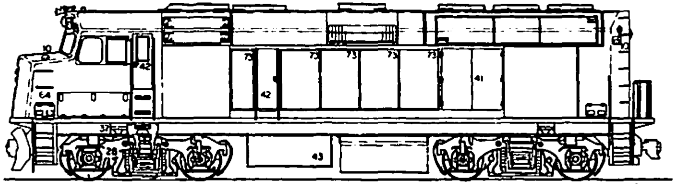
One of the areas where a synthetic lubricant has improved performance has been the Head End Power (HEP) gearbox drive of the F40 locomotive. In early 1982, one locomotive builder experienced rather severe gearbox problems on this model. The Head End Power (HEP) system on this locomotive generates AC power for passenger car heating, lighting, and air conditioning. The system is directly driven by the accessory end of the engine and incorporates a gearbox which allows the air compressor to turn at engine speed, while the alternator rotates at twice engine speed.

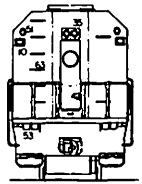
The gearbox is a single stage, parallel shaft, speed up unit. Four bearings are employed to support both shafts; three are roller bearings, while the output shaft has one ball bearing that also supports the weight of the alternator. Lubrication of the gearbox is by means of oil splash being collected at various points and channeled to the bearings.

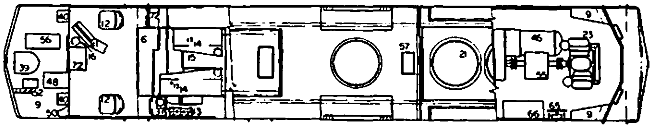
The original lubricant used was an SAE 30, compressor-type oil. Following a series of tests by the manufacturer and Amtrak, recommendations were made to use a synthetic oil for this application. This recommendation was made

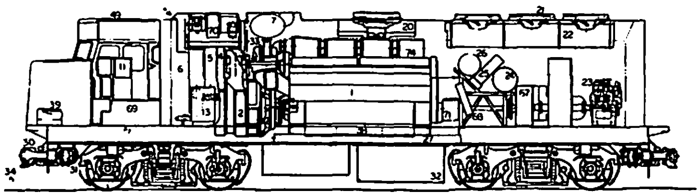
F40PH Locomotive General Arrangement



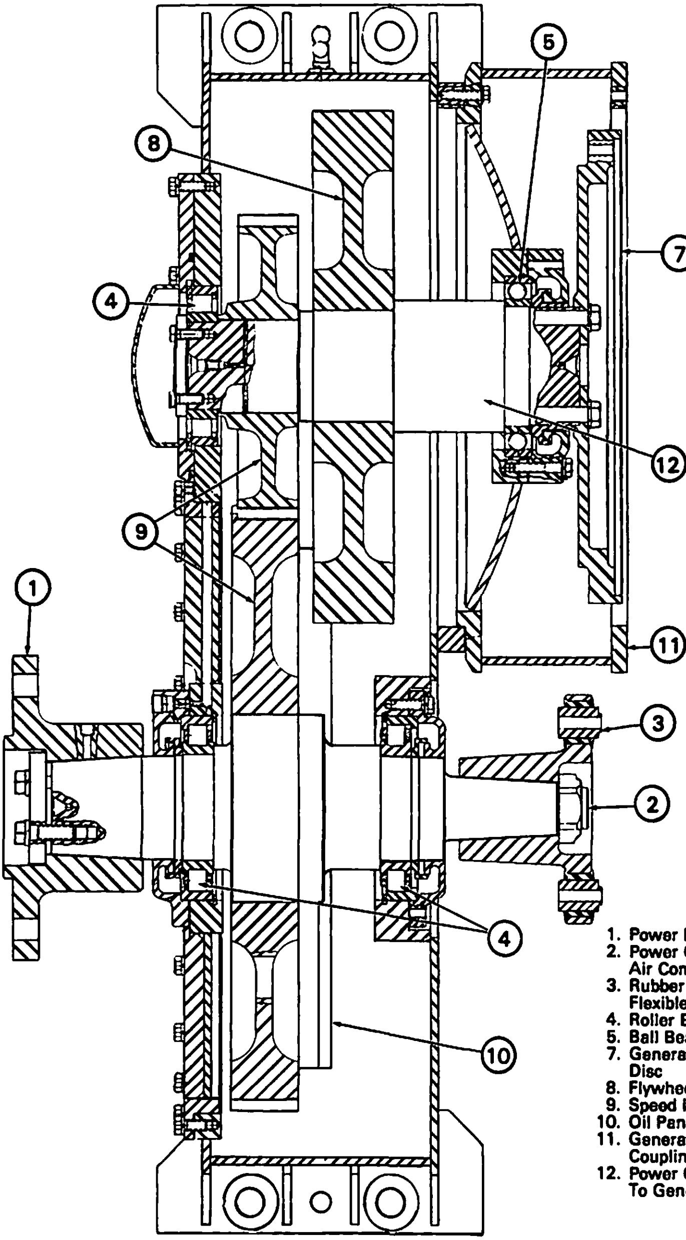








1. Engine 16-645E3
2. Generator - Alternator AR10-D14
3. Auxiliary Generator 18 kW
4. Generator - Alternator Blower
5. Traction Motor Blower
6. Electrical Control Cabinet
7. Exhaust Silencer
8. Batteries MS 420
9. Sand 13 cu. ft./End
10. Sand Box Filler
11. Engineers Control Stand
12. Cab Seat
13. Electrical Cabinet Air Filter
14. Inertial Carbody Filters -
    10 Cell - Right Side
    13 Cell - Left Side
15. Engine Air Filters 12-36 In. Paper
16. Fire Extinguisher - Cab Mounted
17. Water Cooler - Refrigerator
18. Snoe Plow Pilot
19. Horn - 5 Chime
20. Dynamic Brakes
21. Radiator Cooling Fans
22. Radiators
23. Air Compressor - WBG
24. Lube Oil Filter
25. Lube Oil Cooler
26. Engine Water Tank
27. Traction Motor Air Duct
28. Truck - GP Single Shoe
29. Traction Motor D77
30. Coupler Type F W/Alignment
    Control
31. Draft Gear - NC 390
32. Fuel Tank - 1500 Gallon
33. Engine Room Partition
34. Number Box
35. Headlight
36. Emergency Alerting Lights
37. Jacking Pads
38. Oil Pan
39. Toilet
40. Electric Cab Heaters
41. Maintenance Door
42. Personnel Door
43. Battery Access
44. Air Brake Equipment Access
45. Sand Trap Access
46. Electric Head End Power Generator
47. Main Air Reservoir
48. Radio Equipment
49. Provision For Air Conditioning
50. Emergency Brake Valve
51. Classification Light
52. Collision Post
53. Trainline Receptacles
54. Anti-Climber
55. Head End Power Control Cabinet
56. Train Control
57. Engine Room Vent
58. Removable Dynamic Brake Hatch
59. Removable Cooling Hatch
60. Removable Turbo-Exhaust
    Silencer Hatch
61. Removable Inertial Filter Hatch
62. Removable Cooling Fan Hatch
63. Roof Access
64. Short Hood Access
65. Handbrake
66. Head End Power Contactor Cabinet
67. Gear Box
68. Fuel Filter
69. Air Brake Equipment
70. Inertial Filter Dust Bin Blower
71. Lube Oil Strainer
72. Steps
73. Insulated Aluminum Side Panels
74. Exhaust Manifold

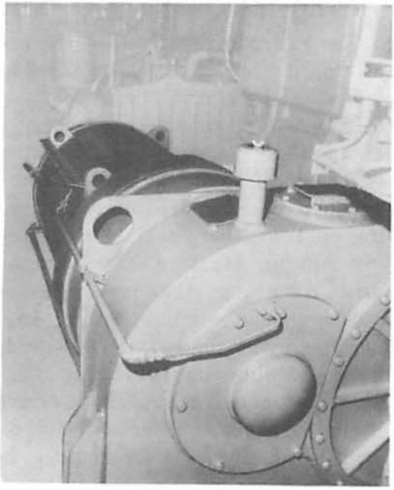


1. Power Input Shaft
2. Power Output Shaft To Air Compressor
3. Rubber Bushings In Flexible Coupling
4. Roller Bearings
5. Ball Bearing
7. Generator Rotor Coupling Disc
8. Flywheel
9. Speed Increasing Gears
10. Oil Pan/Sump
11. Generator Housing Coupling
12. Power Output Shaft To Generator

23856

Gearbox Cross Section

both because of the urgency of the situation and the inherent properties of synthetic lubricants which give them excellent low temperature flow properties, facilitating low-temperature start-up lubrication and excellent high temperature oxidation characteristics, providing extended life under high temperature operating conditions. The good low temperature flow properties of the chosen synthetic lubricant are indicated by its -40° F. pour point in comparison to the +15° F. pour point for the mineral oil.



Bearbox and Alternator

Based on the lubricant viscosity properties recommended by the equipment manufacturer, the synthetic oil was felt to provide acceptable viscosities for bearing lubrication at both idle and at maximum speed, where oil temperature can exceed 200° F.

The properties of the original oil and the synthetic oil are shown in the following table:

Characteristic	Original Oil	Synthetic Oil
Gravity, API	29	34.4
Specific Gravity, 60/60° F	.881	.853
Pour Point, °F, max.	15	-40
Flash Point, °F, min.	470	500
Viscosity		
cSt at 40° C	112-122	365-405
cSt at 100° C	12.65	38.9
SUS at 100° F	588-630	1950-2150
SUS at 210° F	69	189
Viscosity Index	95	145
Color, ASTM	4 max.	3.0

Because of prolonged operation in various climates where oil temperatures frequently exceeded 200° F., it was decided to use an oil cooler to insure adequate service life. A cooler was installed with a circulating pump using engine cooling water as the medium. The cooler was added at the same time as the switch to a synthetic lubricant was made.

Operation of the system for two years has been satisfactory. Oil condition is being monitored by the use of laboratory analysis at 92-day intervals. The most important findings for these analyses have been the occasional detection of incorrect oils being added to the gearbox. Prompt oil changeout, based on viscosity readings, have minimized any problems caused by oil mixing.

Based on experience to date, the synthetic oil has shown good resistance to oxidation and excellent wear characteristics. No final determination has yet been made for establishing a frequency for oil change. The current plan is to make changes based only on laboratory findings.

Amtrak is currently using the synthetic lubricant in 191 gearboxes. Even though the synthetic lubricant costs approximately five times as much as the original mineral base lubricant, the failure rate has been reduced significantly, proving that the lubricant is cost efficient.

Other Synthetic Oil Uses

Another railroad reports that it has standardized on use of a synthetic lubricant in engine governors. The oil used in this application has the following properties.

Gravity, API	34.4
Pour Point, °F, max.	-65
Flash Point, °F, min.	450
Viscosity	
cSt at 40° C	56-60.8
cSt at 100° C	10.2
SUS at 100° F	290-340
SUS at 210° F	61
Viscosity Index	135

The railroad reports that the use of this oil has practically eliminated varnishing and sludge buildup in governors, considerably lengthening their service life. Because of the high viscosity index of the product, the oil performs well during cold weather, particularly during engine starting and just as well during the hot summer months. The elimination of varnishing is attributed to the product's stability under higher temperature conditions. There have been no adverse effects noted on seal or diaphram performance in engine governors on this railroad.

The same oil was also used in a stationary air compressor at a major shop with good results. The compressor was reported running loaded about 70% during its duty cycle. In four years of working under an enclosed high temperature environment similar to that of a locomotive, the compressor has not suffered any downtime because of mechanical failure. The oil has been changed several times. Inspection of compressor components including valves have shown them to be in good condition.

The oil was also tested in a passenger locomotive air compressor, but the test was inconclusive because of oil mixtures caused by the addition of the railroad's standard oil.

FUEL & LUBRICANTS COMMITTEE

Six-Year Index

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 Material Control 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.

Monday, September 24, 1984

3:10 P.M.

REPORT OF THE COMMITTEE ON DIESEL MATERIAL CONTROL

Pre-Convention Presentation: Omaha, NE

April 12, 1984
Red Lion Hotel
Omaha, NE

F. A. BLUNDON, Chairman
Director Material
Burlington Northern Railroad
St. Paul, MN 55101

COMMITTEE MEMBERS

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R. E. Marler	Dir. Prod. & Cost Control	UP	Omaha, NE
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G. A. Taylor	Master Mechanic	MoPac	Houston, TX
D. C. Woods	Senior Systems Coordinator	EMD	Hodgkins, IL

1984 TOPIC:

"MATERIAL CONTROL IN A CHANGING ENVIRONMENT"

PERSONAL HISTORY

FRANCIS A. BLUNDON

Born in Lincoln, Nebraska on April 22, 1929. He attended public schools, the University of Nebraska, and Lincoln School of Commerce, all in Lincoln, Nebraska.

He was employed by the Chicago, Burlington and Quincy Railroad Company on September 24, 1951, in the Material Department at their Havelock Shops in Lincoln, Nebraska. He worked on various jobs until being promoted to Chief Clerk in Chicago on February 1, 1965. He held several managerial positions in Chicago until he was appointed Assistant District Manager Material on March 1, 1970, when the Chicago, Burlington and Quincy Railroad Company became part of Burlington Northern, Inc. He was appointed Material Manager at Havre, Montana on February 1, 1971, Regional Manager Material at St. Paul, Minnesota on March 1, 1974, and Director Material, Twin Cities Region, on January 1, 1984, the position he now holds.

Fran is married to the former Laurie Ann Pike of Lincoln, Nebraska. They have one daughter and two lovely grandchildren. He enjoys gardening, golf, hunting, fishing and most spectator sports.

MATERIAL CONTROL IN A CHANGING ENVIRONMENT

Introduction

The theme of the 1984 Diesel Material Control Committee paper is "Material Control in a Changing Environment." Some new ideas and technology are being developed and implemented which, when in place, will be helpful in our efforts to provide maintenance material on a timely basis at the lowest possible cost. Mechanical and Material Department officers should be interested in these new concepts because their successful implementation will affect budgets and ultimately the "bottom line" in a very favorable manner.

The papers presented by this committee are intended to create interest in these new concepts and generate some activity that will result in improved productivity and reduced maintenance costs. The papers to be presented are:

1. Bar Coding of Material.
2. Forecasting Material Requirements.
3. a. Fuel Security—Are You Getting What You Pay For?
   b. Fuel Oil is Expensive.
4. Pros and Cons of Material Purchasing Contracts. (Single Source—Just In Time Inventory)

I.

THE NEW LANGUAGE OF BAR CODES

Introduction

You can hear the sound of electronic beeping in almost any grocery store these days. Each of the beeps is the modern sound equivalent of what the supermarket used to do before technology came to the check-out line: Punch the keys on a cash register. The beeping sound is a bar-code reader which is faster and more efficient than punching a half dozen keys on a cash register and does it without making a mistake. Now the clerk grabs the item and passes it over the bar code reader and puts it in a bag—all in one motion.

Application of Bar Code Systems

Newly developed bar-code systems can provide massive productivity leverage for many companies and opportunities abound throughout all industries to apply bar code systems. For inventory control, warehousing, production control, and labeling, bar code systems are now being installed to replace manual tracking systems and computer punched card systems. The reasons for this transformation are simple: Entering data by hand is time consuming and error prone, while the use of bar codes speeds up the collection of data and improves the accuracy of input.

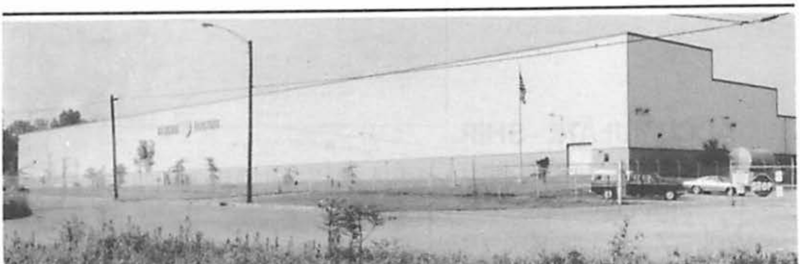
General Electric uses bar code systems to track and record the flow of components through many stages of the manufacturing process. In addition, bar code systems have been installed in its parts distribution center at Erie.

Following is an update on the use of bar code systems at General Electric's Parts Distribution Center in Erie, Pennsylvania. We also review future applications for bar code systems and make suggestions and recommendations for the use of bar coding among United States railroads.

GE Distribution Center

Beginning in 1980, General Electric initiated a project to modernize its Parts Distribution Center at

Parts Center Modernization Project



General Electric Erie Parts Distribution Center

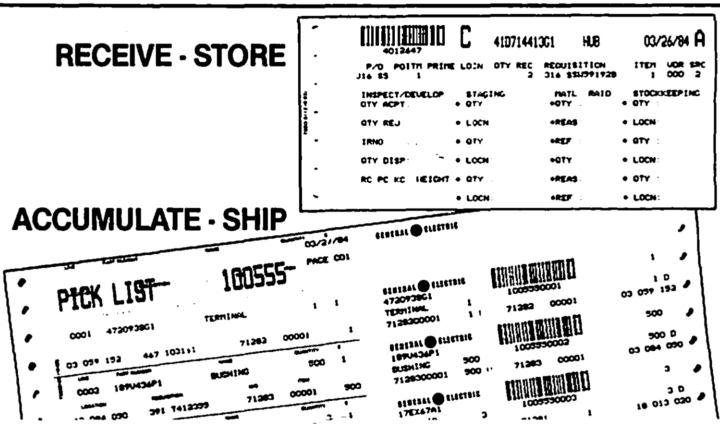
Erie. Built in 1971, the 150,000 sq. ft. facility is responsible for receiving, packaging, storing, and shipping 190,000 line items annually. With sales and volume growth, the parts warehouse overflowed into off-site warehousing which brought with it all of the usual problems of coordination, picking productivity, and shipping from and between multiple locations. Also, with increasing throughput, material flow through the warehouse was slowing down. Under the existing procedures, material flow was accounted for by means of manual checking material when received and when shipped from each process station. When computer card decks were used, this flow could be very slow due to cards being turned in late, errors in count, and further delays in batch processing of computer card records.

Warehouse Modernization Project

To help solve these problems, the locomotive division called in GE's Corporate Consulting Services Operation for assistance. With their help, a self-appraisal was conducted; a program evolved to introduce contemporary materials handling and storage systems as well as a new warehouse computer system utilizing bar coded input from several key material handling locations within the distribution center. The new automated storage and handling equipment is controlled by a dedicated warehouse computer system. The computer, a Honeywell DPS-6 mini-computer, receives input from thirteen bar code readers located at key strategic locations throughout the warehouse.

The material flow through the warehouse can be described as two separate processing cycles:

Warehouse Processing Cycles



* Receive—Store
* Accumulate—Ship

Under the "Receive—Store" cycle, material may be routed through one or several activities after receipt, inspection, development packaging, bulk staging, light pack, heavy pack, and stockkeeping. With bar code tags assigned at receipt, material is scanned as it passes through each activity and the computer updated with the current status of each part.

The second processing cycle is "Accumulate—Ship" and is the order servicing cycle. The computer makes a match of current orders against inventory and issues picking instructions to the warehouse in the form of sequenced pick tickets. The "pick" is then recorded as it passes through the dispatch area and read by a bar code scanner. Thus, as material flows from receiving to storage to dispatch, each operation is "read" by bar code scanners and the computer inventory balanced and order status updated instantaneously.

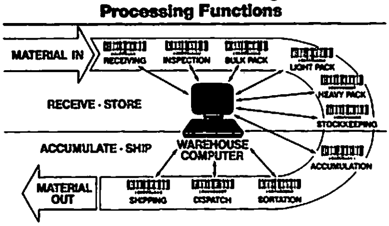
The objective of the bar code system is to maximize the effectiveness and efficiency of the day-to-day warehouse operation. With up-to-the-second information of the status of each part in the warehouse, the computer tracks back-ordered material for receipt and prompt shipment, sequences the picking and storing activities to optimize employee productivity, and traces the flow of material through the warehouse. The computer also maintains the location and stock status of each part stored in the warehouse. Finally, the computer maximizes the utilization of storage space by allowing for random storage of parts in any open location.

Results of Modernization Project

Results of the modernization program are impressive. Completed in 1983, several significant gains have been realized:

* Virtually all shipments are now processed through the warehouse in less than 24 hours. Previously, warehouse shipments were processed in an average of 2.5 days.
* Productivity increased by 50%.
* Off-Site storage completely eliminated, with 10% greater utilization of floor space and 30% increase in cubic storage capacity.

Material Flow Through Processing Functions



Moderization Program Results

- 98% OF SHIPMENTS PROCESSED IN LESS THAN 24 HOURS
- PRODUCTIVITY INCREASED BY 50%
- 10% GREATER UTILIZATION OF FLOOR SPACE
- 300% INCREASE IN CUBIC STORAGE CAPACITY

The Future

There are more than 50 different bar codes in use today. The grocery clerk was no doubt using the "UPC," (Universal Product Code), found on all consumer products. The U.S. Department of Defense requires that all of its suppliers affix a different bar code known as "3 of 9." The name 3 of 9 comes from the fact that each character is represented by a combination of nine bars and spaces, three must be wide. So the code must be 3 of 9 or the scanner will not read it. GE Parts Distribution Center uses a new code known as "Code 128." This code was selected because it has the advantage of "compressibility," (as a result of its narrower bars and spaces, more information can be coded in the same space). It is also self-verifying and it can accomodate both upper and lower case characters.

Scanning equipment used by GE in its warehouse can read both code 128 and code 3 of 9. In addition, the computer and bar code printing equipment has the capability of printing most codes in use today.

Future plans for the use of bar code systems include having all vendors fix bar code labeling to shipments so that receipts can be scanned on the receiving dock, further expediting the flow of material through the distribution center.

Bar codes will also be assigned to customer shipments. Customer purchase order identification, requisition number, part class and item number, can be provided via bar codes. In fact, most any type of information, in any one of a number of different codes can be supplied with each shipment.

In summary, bar codes are now being used to track parts within manufacturing facilities, to trace critical parts, and for the storage and retrieval of finished products. Bar code systems also extend into order departments, shipping rooms and receiving docks. The data collected by scanners are used to update order status and generate shipping documents and labels. In the near future, they will be used to cube the truckloads and assign trucks and shipping dates. The list goes on; it seems to grow each month.

Bar Codes on the Railroads

With ACI, (Automatic Car Identification), Railroads were early users of bar code type reading technology. While the railroads have long recognized the potential savings of this technology in car identification and tracking, the sensitivity of equipment to misread dirty codes on dirty boxcars, together with the inability of the railroad to "recycle" the car to be read again, caused the railroads to abandon early ACI systems. Present day bar code equipment avoids the problems of the early ACI systems. For one thing, industrial bar code scanners operate in cleaner, more easily controlled environments. And the equipment is far more accurate. The error rate

Future Bar Code Applications

1005550010

- SHIPPING NOTICES
- PURCHASE ORDERS
- CATALOG NUMBERS
- PART CLASS AND ITEM NUMBERS
- REQUISITION NUMBERS

Why Use Bar Codes?

1005550009

- TRACKS BACK ORDERED MATERIALS
- SEQUENCES PICKING AND STORING
- TRACES FLOW OF MATERIAL
- MAINTAINS LOCATION
- MAINTAINS STOCK STATUS
- MAXIMIZES USE OF STORAGE SPACE

for the "3 of 9" and "128" bar code has been tested at one error in every three million characters. This level of accuracy is just not achievable from people. In order to equal it, a stockman would have to read and record a 15-character identification label on 200,000 parts without making more than one error.

Opportunities abound within railroad facilities for applications of bar code tracking technology. Consider, for instance, that within the locomotive maintenance facility, tracking and accounting for parts material can be a slow and labor intensive job, burdened with necessary paperwork. Needed material can be delivered at the receiving dock but is not usable until properly checked-in and recorded. After receipt, material can seemingly be lost, only to show up at a later date in another location. Accuracy can be improved. A high percentage of a railroad's "overages and shortages" and material losses is traceable to errors of receiving shipments. Paperwork and its cost can be reduced, accounting procedures streamlined, and error rates substantially reduced through the use of comprehensive bar code recognition systems.

Two other related benefits resulting from the installation of bar code systems in the railroad maintenance facility; it provides an accurate track of material for the proper assignment of material costs to the using department; and, because an accurate inventory record is always available, the annual one

LESS THAN
ONE ERROR IN EVERY
3 MILLION CHARACTERS

1005550003

Additional Benefits of Bar-Coding For Railroad

1005550014

- ACCURATE MATERIAL COST ACCOUNTING
- ELIMINATES PHYSICAL INVENTORY SHUTDOWN

week "blackout" for the taking of physical inventory can be avoided.

Conclusion

Within the past year, many new words have become part of the colorful language of railroading. New buzz words, such as: robotics, solid state, micro-computers, to name a few, together with a whole family of "computer-aided" acronyms such as, CAD, CAM, CATS, CAP are now in everyday use. To this list of new terms should now be added, "bar codes." Bar code is not only a new term, but also a language to itself, a spoken language that sounds like this . . . Beep . . . Beep!

II.
FORECASTING MATERIAL REQUIREMENTS

Recently one of the railroad suppliers sent crystal balls to its railroad customers as a reminder and way of getting them thinking about their future needs. Actually, railroads today do not have to depend on crystal balls and guesswork to project their needs. The development of extensive computer programs and use of other electronic aids have taken the guesswork out of forecasting material needs.

Departmental Planning

The first step in forecasting material needs is for the railroads to determine the condition in which they want to maintain their locomotive fleet and estimate their power requirements.

Power requirements are arrived at by different railroads by various methods. Usually the locomotive fleet is broken down by two or three groups which are intended for a specific operation such as transcontinental or general freight or may be further broken down to TOFC or coal train use, for example. Generally traffic projections furnished by market research will give an estimate of ton miles expected. The total horsepower required for each group is then adjusted with availability or not used ratios, as well as bad order, or out of service ratios.

After appropriate adjustments to horsepower are made, then horsepower is calculated to handle the projected gross ton miles of traffic.

Usually, a joint decision is then made by a number of people to determine the locomotives which should be retired, generally because of age and availability, as well as requirements of new power to achieve the horsepower required to handle the projected gross ton miles of freight traffic.

One major railroad feels very strongly about remanufacture of locomotives as a way of upgrading and maintaining the locomotive fleet.

The classified repairs of locomotives are usually based on the mileage accumulated by the locomotive and/or the number of years since the last overhaul or classified repair. This span of time or mileage may vary considerably depending upon the type of service

in which the locomotive is operating. One criterion used is six years or 600,000 miles in most cases of major engine work.

At every other major overhaul, or 1,200,000 miles, the locomotive would receive a complete rewire and other major components including trucks completely refurbished.

Procurement of Forecasted Materials in Railroad Inventory

After the using department has determined the level of power needed and means of achieving this goal through remanufacture, classified repairs or purchase of new locomotives, it then becomes the responsibility of the railroad purchasing and materials department to procure the necessary material and make it available to the using departments when and where it is needed.

To achieve this goal, it is necessary to determine availability or lead time on the thousands of stock items maintained by the railroads, and order accordingly.

The methods of defining this lead time differ from railroad to railroad. As an example, a recent survey shows:

RAILROAD "A" — Lead time is computed as the period between the date the request is initiated in the field (material department) and the date the material is received at that location, computed using known factors in internal processing and information received from vendors.

RAILROAD "B" — Lead time is computed as the length of time from the date of the purchase order to the date of the first receipt, computed using known factors in internal processing.

RAILROAD "C" — Lead time is computed as from the time the purchase order is placed until material is received plus seven days.

As you can see from the above definitions, computation of lead time differs among the railroads. To convert this into actual days, listed below are ten common items for railroad repair showing the variance of days among the three railroads.

	Lead Time Days		
	Railroad		
Description	"A"	"B"	"C"
Bearing No. 8136114 Connecting Rod, Lower	30	20	26
Bearing No. 9526108 Traction Motor Support	30	13	16
Bearing No. 8354118 Connecting Rod, Upper	30	20	25
Brush No. 9322058 Traction Motor	30	15	27
Cartridge No. 8402068 Air Compressor	30	20	18
Case 9540306 Traction Motor Gear, Lower Half	30	25	19
Holder No. 8331061 Brush	30	15	25
Liner No. 9324108 Pedestal	30	20	20
Ring Set No. 9316112 Piston	30	30	17

As the lead time developed is used in the computation of the amount of inventory that a railroad maintains and thus affects the value of the inventory, it is important to reduce this lead time as much as possible, while still maintaining the required service level.

Some of the ways that are used by railroads to reduce this lead time:

1. Transmission of orders from field store locations to central purchasing via CRT (Cathode Ray Tube).
2. Informing vendors regarding usage of material and estimating quantities of year's need in order that vendors may schedule production.
3. Use of local vendors and vendors with warehouse facilities near the railroad mechanical facilities.
4. Issue of scheduled orders to vendors covering year's need, showing shipping dates.
5. Use of computer generated automated purchase orders.
6. Extensive repair of components in the railroad shops.
7. Direct telephone order from the railroad into the vendor's computer.

In addition to the railroad's responsibility to advise the vendor of its needs, the vendor also has the responsibility to advise the railroad when it becomes aware of circumstances that might increase this lead time, such as material shortages due to manufacturing problems, quality control, labor problems, etc., so that the railroad can adjust accordingly.

Forecasting of Material Not In The Railroad Inventory

Besides the majority of stock items, there are always parts that are not used very frequently and therefore are not stocked. While the number of these parts is not great, failure to have them can cause delays in repair to a locomotive. The ability to forecast need for this type of item is very difficult; therefore it is desireable to keep the quantity of non-stock items to a minimum. To accomplish this, it is necessary to establish a purchasing history of the items as the need arises. Some of the methods used in setting up this history are:

1. Make manual file card side record of order.
2. At first request, set up item in inventory "as required" and let computer capture subsequent activity.
3. Develop a program in the computer to capture non-stock item history based on vendor part numbers.
4. Use information furnished by vendors, where available, to purchase non-stock items.

Once this history of activity is established, based on individual company policy in regard to quantity, price of item, and frequency of use, the item can be included in the inventory and forecast of use is readily available.


WASTE OIL
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TREATED
NOW
RECYCLE
WASTE DIESEL
ENGINE OIL

Consideration of obsolete parts can also be included in this section. Most vendors, as well as railroads, keep a close watch on the inventory and when an item is not sold or used for a specific time the item is classified as obsolete and removed from the inventory.

In some cases a need might develop for this part on the railroad and a substitution must be found. This process often takes a great deal of time and results in holding up repair to the locomotive.

Some steps that can be taken by the vendors and railroads to obtain this type of material:

1. Check for substitutes.
2. Go to other railroads, alternate vendors, scrap dealers, and firms that remanufacture locomotives to see if it is available.
3. Manufacture or repair in the railroad shop.
4. Use local machine shops who can make specialty items.
5. Rob from locomotives that are being held pending retirement and disposal.

In this same connection, some vendors have a policy of notifying their customers whenever an item is discontinued and where possible furnishing a cross-reference of the part number that can be substituted. This service on the part of the vendor is of value to customers in that should a need arise, it can be handled without delay.

Alternate Sources of Supply

Alternate sources of supply to the original equipment manufacturer are thought by some railroads to be advantageous in holding down lead time, controlling prices, and improving the product.

To develop alternate sources, a cross-reference of items and vendors can be used. Some effective methods used by railroads in developing this cross-reference of alternate sources are as follows:

1. Use the Thomas Register.
2. Send inquiries to vendors that might be interested, giving them an opportunity to bid.
3. Ask for suggestions from all field personnel.
4. Solicitation of business by vendors through personal calls or correspondence to the railroad.

After the alternate part is developed, some railroads require that a sample be furnished by the vendor and sent to the using department. The using department will examine the part and, depending on what the part is and where it is used, may require a test either in service on a locomotive or by analysis in a test laboratory. Based upon its findings, the using department will approve or disapprove the part. If approved, the alternate vendor name and part reference is included in the railroad inventory records and purchases made on the basis of price and availability.

To summarize, accurate forecasting of material requires close communication on the railroad between the using departments; to first determine their needs, then with the Purchasing and Materials Depart-

ment to purchase the material and make it available when needed.

Communication from the railroads to the suppliers is required to keep the latter advised of needs so that orders can be promptly filled. When advance notice is given the supplier, he then has a responsibility to ship the material as specified by the railroad.

The ordering of non-stock items should be kept to a minimum by developing purchase history. Also important are communication between suppliers and railroads when problem areas arise in procurement; advice by the supplier whenever an item is made obsolete, with the recommended substitute part reference; also when a new product is available or an improvement made on an existing one, and cooperation between supplier and railroad in the testing of new or improved products to determine if the railroad specifications and needs are being met.

IIIa.
FUEL SECURITY
ARE YOU GETTING WHAT YOU PAY FOR?

Introduction

Since 1967, fuel costs for American railroads have increased almost three times more than all other operating costs, including wages. Fuel costs alone, within that same time period have multiplied by more than ten times their 1967 figure. With a commodity so valuable and essential to railroad operation, security and control methods of the 1960s are simply obsolete.

Magnitude of the Problem

In an effort to determine the magnitude of the problem, the Police and Security section of the AAR conducted a survey in April 1981. Response to the survey was limited, but can be considered representative of problems being experienced by the entire industry. If that assumption is correct, fuel oil theft can be considered as costly as the problems of journal brass and copper wire thefts which have plagued our industry for years.

During 1979, it was discovered that one railroad lost more than 1.7 million gallons of diesel fuel in one case alone. The loss of another railroad has been estimated at 5% or 7.5 million dollars, of the annual fuel delivered by highway tank trucks which totals approximately 150 million gallons a year. The same railroad reported that in 1980, two employees were held responsible for the theft of over $20,000 worth of fuel from one location alone. One railroad reported that approximately one and a half to two truck loads a week were lost over a period of many months at an unmetered location where an employee failed to follow instructions to check every delivery. A meter was subsequently installed and was sabotaged by truck drivers to allow the thefts to continue.

One railroad reported that at least seven truck loads were lost at a metered location where the driver was pumping in one side of the meter, through the meter and via a valve on the other side of the meter back into his truck.

One railroad reported that at an unmetered location a truck driver was caught trying to leave the yards with 2,000 gallons still on his truck.

One railroad also discovered at an unmetered location, that a truck driver was stopping off at a filling station and dropping off several hundred gallons prior to delivering the rest to the railroad.

Sometime ago, a railroad discovered that at one location a check valve had been altered, with the collusion of an employee, enabling one truck driver to pull in empty, load his truck from the storage tank and still charge the railroad for a delivery.

Responsibility

The responsibility for the security of fuel cannot rest on any one department. This responsibility must originate within the top levels of management and permeate every organizational entity of the company. There also is a need for increased communication and cooperation between railroad companies. As fuel security measures become more effective, the criminal subculture will improve its technology. Fuel thieves will seek opportunities from railroads having the weaker controls. Communication and cooperation can play an important role in literally drying up their livelihood.

In a similar manner, awareness of the fuel security methodology must transcend all areas of responsibility from engineering to auditing. Each person with a responsibility for fuel security and control should understand all aspects of the total program.

Methods of Delivery

Fuel will be delivered from suppliers to using railroads by one or more of the three following methods:

Pipelines: Although delivery of fuel by pipeline provides the best apparent security, that method is the least commonly used.

Railroad Tank Cars: There have been instances where problems have been revealed with this method; for example, one supplier billed the railroad according to the stenciled capacity of the car. A loading foreman verified that each car was filled to capacity by visual observation during the tank car filling process. An investigation revealed that the foreman's visual inspection was consistently short. Even when dealing with reputable suppliers, a study of the loading and billing procedures should be conducted.

Tanker Trucks: Although the greatest number of problems have been discovered in this mode of delivery, the majority of suppliers and operators are honest and many of the mistakes are made without criminal intent.

Facilities and Equipment

The engineering design and selection of equipment for the fuel receiving storage and distribution facility can play an important role in reducing the magnitude of the problem. Without proper equipment, it is possible not only to pay for fuel which was not delivered, but also, as already mentioned, some losses have been documented where empty fuel trucks, under the pretense of making deliveries, have left railroad property filled with fuel from the railroad's storage tanks.

To rely too heavily on equipment alone, however, could be a costly mistake. Even the most sophisticated equipment available cannot totally prevent the theft of fuel oil. A foolproof system, if it actually existed, would involve proper planning, good equipment and adequate manpower.

To discourage irregularities by the operators of fuel delivery trucks, the driver's options should be restricted. Delivery trucks should never be allowed to roam about railroad property unchallenged. Proper roadways, fencing, markings and turn-around areas can prevent this. The structures enclosing necessary pumps, filters and valves should be designed to deny access by delivery operators. In areas where locked doors are precluded by fire codes, alarms should be installed to alert appropriate company personnel of unauthorized entries. The design of the structure should be such that any connections, valves, or meters to which a delivery operator must have access are easily available for his use in a clear, uncluttered, well lighted area. Everything else in the system should be protected from his reach. Clear instructions for the operator's procedures should be posted. A telephone/intercom can be helpful in resolving special problems that may occur.

Any equipment to which the delivery operator is allowed access should be tamperproof. Meters should be protected with cages or seals. Check valves should be of the type that cannot be manually circumvented. Air vents should be unblockable.

Deliveries from gravity-fed trucks should be made on level ground. For this reason, a level concrete slab at the reeciving area is most appropriate.

A wide variety of satisfactory equipment is available and the selection of that equipment depends on the local circumstances.

Let us now discuss some of the components of a typical installation and the part they play in fuel security.

The air eliminator is used to vent free air or vapor at the meter inlet. When liquid entering a meter contains air or vapor, the meter will measure both the liquid and the air or vapor, resulting in inaccuracies. Some air is almost always present at the beginning and end of the tanker unloading procedure. Without the air eliminator, the metering unit could record a substantial amount of air. During operation, the vent line of the air eliminator must remain unobstructed. By manually blocking

the vent line, the air eliminator becomes inoperative, thereby allowing the recording of air by the metering device. In some installations, this vented air is used as a signal to check the flow of liquid in the main flow lines.

In most systems, however, the air is released to the atmosphere. Small amounts of fuel are relieved through the vent system. However, in a well-designed system, this fuel is salvaged in a container for miscellaneous fuel uses. Even the salvage container must be vented, however, and air vent design should prevent manual obstruction of the venting system. Again, blocking the vent could cause the meter to record both air and liquid measurements.

It should be noted, however, that air eliminators have limitations. They function effectively to remove large "bubbles" of air such as those caused by air in the hoses during coupling or the drawing of air after the tanker has emptied. On the other hand, the air eliminator may not help at all in cases where tiny bubbles of air have been thoroughly mixed with the liquid.

It was recently learned that a common practice for tanker operators is to cause the tanker to expell a foamy liquid which defeats the equipment.

Tanker trailers are normally compartmentized with outlets feeding through valves on each compartment to a common manifold and then to the pump. The process involves the draining of one compartment so that it is void of product. The pump, which is normally powered by the tractor engine, is "revved up" to a speed much greater than its normal operating speed. Then during the transfer of the liquid, the operator blends air from the empty compartment with the product from the other compartments. Because of the thorough suspension of air in the foamy liquid, the foam will pass through the air eliminator and the meter, where a greatly exaggerated volume reading is indicated. The foaming process is easier when the viscosity of the liquid is increased by cold weather.

Both detection and prevention of foaming is difficult where deliveries are not monitored by company personnel. One possible solution would be the mandatory weighing of all incoming and outgoing delivery trucks. Where this is not feasible, spot checks with portable scales could provide some deterrent to the practice of foaming.

Where check valves exist in a system, their purpose is to prevent reverse flow of the fuel. Check valves should be tamperproof to prevent them from being rendered inoperative. An inoperative check valve, by allowing reverse flow, would make removal of fuel from the storage tanks possible.

The base sediment and water monitor is used to detect the flow of water into the fuel system. The probes are normally installed near the inlet of the system. They can

be arranged to sound an alarm, shut down a pump, close a solenoid valve, or divert the flow when water is detected. Without such a device, the transfer and metering of large amounts of water are possible.

The meter consists of a housing in which entering liquid is measured by volume. This information is transmitted mechanically to a register where the measured amount is displayed. In some systems, this mechanical coupling is routed through a temperature compensator. Since the meter unit itself is a sealed unit, other than protection from tampering, no special considerations are needed. The unit as a whole, with all the components should be protected against tampering by adequate seals or by an expanded metal cage, or both. Without such protection against tampering, the meter assembly is vulnerable to one or more of several acts which would either disable the device or create serious inaccuracies. An adjuster, used during the calibration of the meter, is located on some meters behind a faceplate. Manipulation of this device could cause a meter to read numbers greater than the actual amount of fluid passing through it. The distance between the components of the meter assembly itself is critical. The installation of shims between the meter and register bodies could result in inaccuracies. Most exposed bolts on the meter assemblies are drilled for sealing wires. Policy should dictate that these are effectively utilized.

A register with large numerals provides a visual readout of the amount of fuel entering the storage system. This amount is usually reset before each load is delivered. A second, smaller set of numbers, the totalizer, does not reset during each fueling cycle, and records a cumulative amount instead. These totalizer readings can be very useful for adequate accounting controls.

Although the register provides a visual readout during delivery for monitoring purposes by company employees, one railroad blanked out the visible register readings. This idea has merit. Not only can company employees monitor the input, but this same reading can be seen by delivery personnel as well. It is conceivable that a delivery operator may stop the transfer of fuel as soon as the railroad meter indicates the supplier's ticket amount; or is within a given railroad's acceptable tolerance (some railroads have established tolerance limits within which they will not challenge the delivered amount for payment purposes). If, for some reason, the meter was reading short, the railroad would incur a loss. Overages and shortages should balance out over a period of time making the transactions equitable to both the railroad and the supplier. Consistently short deliveries, even if only by several gallons, would serve as an advantage to the supplier at the railroad's expense.

Additionally, a visible railroad input register may provide other

opportunities for dishonest acts. In either event, the final reading is visible to the operator after completion of the transfer, upon activation of the ticket printer.

A pulser, which is an electronic sending unit, may be used to operate devices at a remote location such as a remote totalizer or printer. This offers the advantage of being able to monitor inbound deliveries from a remote location such as the stores department, accounting office, or by a fuel control officer. The mere presence of a pulser, even though not connected, could provide a good psychological deterrent to irregular activities by delivery operators merely by providing the chance that someone may be monitoring their activities.

A ticket printer, normally above the register, provides a means of recording metered deliveries. Where the ticket printer is operated by the tanker delivery operator, ticket controls are imperative. It is possible for operators to possess their own ticket printers which would enable them to print any gallon amount on a ticket to be submitted. In most meters, a single handle imprints the ticket and resets the register at the same time.

Fuel Delivery Tickets

Fuel oil users are normally billed according to records established by the supplier at the time of loading of the tanker truck. Without inbound meters, it is difficult to verify that all of the fuel loaded by the supplier into the delivery vehicle was actually delivered to the railroad. Where inbound metering equipment is available, however, the delivery is recorded on a fuel delivery ticket of railroad origin. Although fuel accounts are normally paid from supplier's tickets, the railroad ticket provides a good means of determining proper deliveries and serves as an indicator that a problem may exist. For a tanker truck with a capacity of 7,000 gallons, a discrepancy of more than 50 gallons is noteworthy. One railroad company, after maintaining close scrutiny of inbound deliveries and keeping accurate records reduced this maximum allowable discrepancy to a much lower figure. It consistantly found that with proper attention to deliveries, differences between supplier and receiving tickets averaged less than eleven gallons.

For reasons mentioned previously, delivery tickets should be serialized. Ticket printers are available and without proper accountability for tickets themselves, drivers could submit tickets with the proper comparative fuel oil amounts and yet deliver only partial loads of fuel. Regular totalizer reading could check this problem. However, one railroad uses a system whereby the driver is instructed to call the railroad police department for the serial number of the ticket he is to use. Since deliveries may occur at irregular times, a supply of tickets is normally available at the delivery location. Completed tickets are normally attached to a copy of

the supplier's ticket, then dropped through a slot into a secured box. By not allowing drivers to browse through other delivery tickets, additional opportunities for fraud are reduced.

At predetermined intervals the amount of fuel in storage tanks should be ascertained. For comparison purpose, this amount should be converted to net gallons readings.

Electronic Metering Device

The latest equipment now available is a microprocessor based control system designed for continuous on-line, accurate measurement. Without the use of batteries, this unit has the capability of memory retention for up to ten years.

One of the most significant benefits of the unit is the high degree of accuracy obtainable with the automatic temperature compensating feature. The product temperature is measured every one-half to one second for greater accuracy. The ticket printer can be installed in a remote location and be handled by material department personnel rather than the truck driver. This is another method that can insure your company gets what it pays for.

Diesel Fuel Thefts

Many thefts of diesel fuel have been reported and at current fuel prices, these thefts can amount to substantial losses. A series of thefts to one railroad was reported at more than one million dollars.

Most thefts of full trailer loads have occurred where there were no inbound meters for delivery, or where those inbound meters were circumvented by the following methods:

1. Bypassing the meter on inbound lines using either air, water or system deficiency.
2. Bypassing the meter on delivery vehicle.

Thefts of partial trailer loads have been accomplished by:

1. Shorting delivery.
2. Pumping from the trailer, through the meter, back into the trailer.
3. Clogging the air eliminator vent.
4. Pumping fuel off prior to delivery at rail receiving facility.
5. Manipulation of tanker valves and pump during transfer to create a foamy product.

Some delivery operators have successfully fueled their tractors at railroad expense. These thefts have been detected primarily among owner/operator delivery brokers. In general, they have preferred the first load of the day and have chosen the loading terminal or refinery as a location for their crime. A variety of techniques and hookups have been reported, but in general, the procedure normally involves a connecting line from the outbound tractor pump to the cab, and then to the saddle tank. In this manner, the saddle tanks can be filled while pumping off the product. Other techniques have involved separate electric fuel pumps fed from lines connected to the tanker trailer.

Direct Fueling of Locomotives By Vendors

Relatively good control during receiving, storing and dispensing is possible at a permanent fueling installation. When it is necessary to fuel locomotives by pumping directly from a vendor's fuel truck into the locomotive, procedures and controls must change to compensate for the inherent weaknesses of such a system. One major weakness of the direct locomotive fueling process is the absence in the industry of accurate locomotive fuel gauges.

The first control factor should be the elimination of as many of these direct fueling operations as possible. This can be accomplished through a detailed analysis of direct fueling operations and sites, and then reducing the number through scheduling and consolidation. For those direct fueling operations which remain, railroads have taken different approaches. Since a major part of the relations with vendors may depend on trust, some companies depend on extensive background investigations of the selected vendors. Information which is a matter of record about questionable vendors could be shared among railroads in a given area. Before controls are developed and implemented, however, a good identification should be developed. One company has developed an audit program which is printed in its entirety below:

'Audit Programs Directing Fueling of Locomotive by Vendors' Objective

1. To determine those procedures in effect at each location and evaluate those controls that help insure the company receives what it pays for.
2. To compile data from all locations as an aid in developing uniform procedures and controls applicable to all direct fueling locations.

Procedures

1. Visit the assigned location where direct fueling occurs.
2. Determine those company employees who approve vendor delivery tickets and invoices.
3. Determine those procedures followed by the vendor or his driver by (a) observation of fueling that occurs during your visit and/or (b) discussion with company personnel and/or (c) discussion with vendor personnel.
4. Determine those procedures followed by company employees to insure that fuel as indicated on vendor delivery ticket and/or invoices is actually delivered to a locomotive.
5. Audit delivery tickets and/or invoices by use of Mechanical and/or Transportation records to determine if the locomotive(s) shown on the tickets

were at the location on the date and time shown on the delivery ticket and therefore could have been fueled. Note and attempt to resolve any discrepancy.

6. Discuss the fueling operation with local company employees to determine if there are suspicions or rumors that might indicate the possibility of fraud.
7. Provide your evaluation of the adequacy of the present procedures and controls along with any recommendations you feel are needed to improve the adequacy of controls.
8. Provide answers to the following specific questions in separate report:
   1) Who were your primary contacts during your visit?
   2) Do vendor's trucks have meters? Are they used?
   3) Do any company employees observe the actual fueling? How often?
   4) Does any company employee check the truck upon arrival to begin fueling to insure that a new ticket is inserted in the meter and imprinted with zeroes as a beginning meter reading?
   5) Does any company employee observe fueling sufficiently to determine if the truck leaves company property before fueling is completed? If it does, does anyone observe to insure that delivery tickets are removed from meters after the reading is imprinted? In other words, do drivers ride the tickets by leaving them in the meter when leaving company property to refill the truck or for any other reason, then return to resume fueling? This practice permits the potential for dropping off fuel enroute without detection as no interim meter readings are imprinted and the company could pay for all fuel from start to finish.
   6) Do vendor's drivers turn tickets in for signing by company employees promptly upon completion of fueling?
   7) Is fueling done at hours when no company employees are on duty in the vicinity of the fueling operator? If so, when? Is it necessary, and why?
   8) How does the company employee who signs the delivery ticket know that the locomotive was actually fueled? How does he know how much fuel was actually delivered?
9. Does the company tell the vendor what specific locomotives to fuel, or does the vendor routinely come and fuel any locomotives on hand that need fuel without being so directed?
10. Are you aware of any local company employees that have connections with or ownership in the vendor's business?

11. Were there any suspicions voiced by anyone regarding possible fraud?
12. Do we rely primarily on the honesty of the vendor and his drivers or do we really have controls to insure that we are not being "ripped off"?
13. Does the vendor submit tickets/invoices to local company employees for approval and forwarding to Purchasing Department or Accounts Payable for processing for payment, or does the vendor send the invoice directly to headquarters?
14. If the vendor submits billing to headquarters, does anyone in the company match this billing against company records to insure that fake tickets/invoices are not submitted?

This report may contain sufficient information by which you can compare and evaluate your company's fuel oil security methods, but by no means is this report considered to be the last word in fuel security. As controls are tightened, thieves will become more innovative. So, everyone connected with the handling of diesel fuel must continue to search for better ways of getting what you pay for.

IIIb.

"FUEL OIL'S EXPENSIVE"

The importance of fuel conservation has been dwelled on. No one should doubt its significance. At Amtrak, we realized large sums of money could be saved through proper and effective fueling methods.

Amtrak, 16th Street Chicago, presently employs the Rusco-Electronic Fuel Monitoring System, definitely the state of art in fuel control.

Card

The system starts with the card. Any interactions on the fuel system are transmitted to the heart of the computer system which is the Micro Access Controller (MAC 530). The controller will be discussed in greater depth after the outlying components are understood. The card, the size of a credit card, is magnetically encoded on an internally laminated core. The card's security is protected to insure against duplication even if a commercial encoder is available and published manufacturer instructions are at hand.

All dispensing authorization information is programmed in the controller instead of depending on information previously encoded on issued cards. This permits changing authorized status, fueling limitations, cost analysis, etc., without the need to retrieve the old card, encode and issue a new card, which is required with systems using the holarith or magnetic strip card. The "Ruscards" are encoded with binary coded bits in a scrambled pattern as a unique identification code. There are two series of numbers encoded within each "Ruscard," a system code and a sequentially encoded number. The combination of the system code and ID number is unique and no other single card with that combination shall be manufactured.

For longer life brake shoes & grade crossings, you should see red!

COBRA brake shoes and grade crossing surface materials have a lot more in common than their bold red color. Both offer economy and

proven performance backed up by a sales and service network you can depend on for expert advice and quick response.

COBRA brake shoes are made from a composition material that can last up to four to five times longer than metal shoes. They can increase the life expectancy of car wheels up to double that with metal shoes.

COBRA grade crossing surface materials offer similar performance benefits. Light-weight high density polyethylene COBRA sections are palletized, pre-cut and pre-drilled to bolt directly to properly spaced crossties for speedy installation. In an actual installation, a crew of six installed a single 42′ track crossing in just four hours. Once installed, they are highly resistant to abrasion, moisture, solvents, road salts, shock and wear.

The next time you need brake shoes or grade crossing surface materials, you should see red. COBRA red.

For more information, write:

Railroad Friction Products Corporation, Wilmerding, PA 15148.
In Canada, Cobra Friction Products Ltd., P.O. Box 2050, Hamilton, Ontario L8N 3T5.

Cobra®

Each vendor is issued a "Ruscard" specifically programmed with driver's name, company and essential ID number, if necessary. Should the driver change or require new cards, the original card may be canceled from the system and made immediately invalid.

No fuel delivery count or fuel dispensing can be accomplished without first inserting the appropriately programmed card at the APT (Automated Petroleum Terminal).

Automated Petroleum Terminal — Delivery

The driver will insert his card into the APT and may key in various data, such as job ticket number, at the delivery site. Fuel is then pumped from the truck to Amtrak storage.

A pulser attached to the flow meter will transmit to the system printer the nearest gallon of delivery after the water and air have been eliminated. An FDM module will simultaneously measure the water separated from the delivery. This information is recorded on the printer.

Printer — The System Activity Logger

SAL 510 provides a hard copy event recording in clear text. The logger (printer) serves as an output device for the controller (MAC 530) and will record system access events (transactions) consisting of transaction code, card holder ID, status level, reader location code and time (day of year, day of week and time of day). Alarms, including "equipment tamper" and "invalid card entry" are highlighted by specific descriptive definitions and a series of asterisks for fast identification. In addition, an alarm is sounded at the controller (MAC 530).

Automated Petroleum Terminal — Dispensing

The APT 500 gathers data and processes through the MAC 530. This information can be stored on an optional diskette, magnetic tape or printer. The dispensing unit functions in much the same fashion as the delivery APT. The APT is a self-prompting unit and will guide the user through each step. A typical one-card transaction would proceed as follows:

A) The "insert card" light will already be on if unit is ready. The operator will select hoses #1-6 and push "SEND" key. If selected hose is in use, "Hose in Use" light stays on. This process is repeated until an available hose is selected.

B) Once an available hose is selected, the "enter odometer/data" light turns on.

C) Operator inputs locomotive number and depresses "SEND."

D) The "Hose Ready" light is turned on and all other lights are extinguished, the operator goes to selected dispenser and pumps fuel.

Micro Access Controller

MAC 530 contains the control, memory and monitoring functions of Rusco's system. The unit serves as a micro-processor with great flexibility access control and operations monitoring systems. This field expandable unit contains a multitude of optional features.

— APT devices to monitor automobile fuel and assist in forecasting maintenance.

— Memory buffer devices to store data which can interface directly to an on-line computer.

— Automobile traffic flow using extensive line of equipment for the parking industry.

— Data collection devices for use in inventory control of parts, supplies, tools and any valuable items.

— Time and job cost control using existing equipment in product line.

— Security access to restricted areas.

Many fuel monitoring systems exit and run the gamut of expense and optional features. The fuel problems once experienced by Amtrak have not disappeared, but a much greater control, as the result of a computer operated system, is leaving some of the wasted high costs of fueling behind. Although final figures have not been received, it is believed that the 16th Street fuel system presently in use will pay for itself in less than a year and a half.

IV.

PROS & CONS OF MATERIAL PURCHASING CONTRACTS

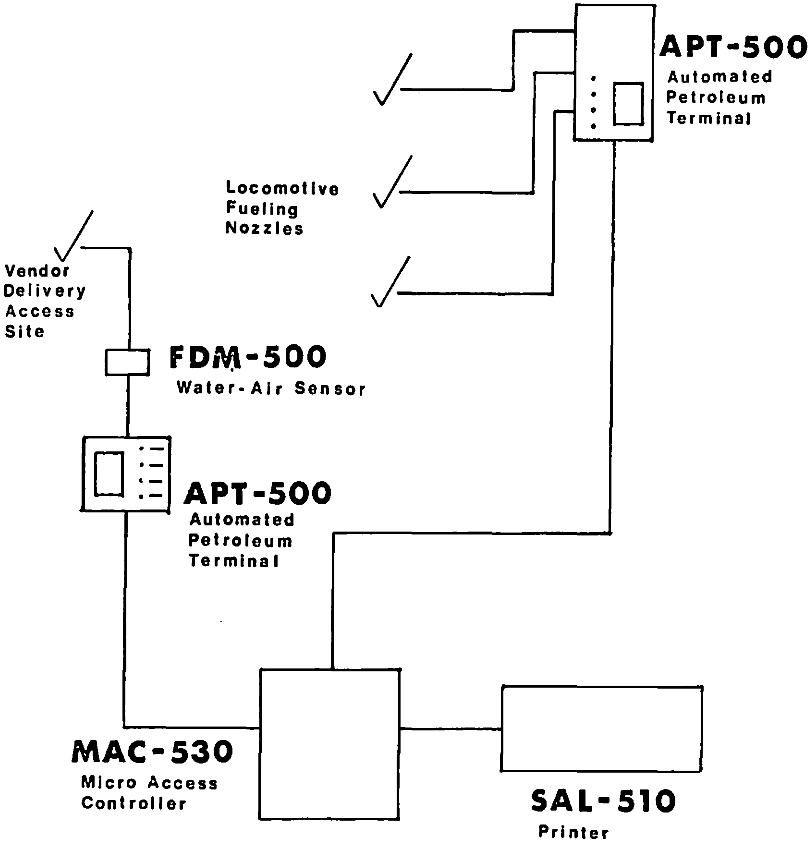
(Single Source — Just In Time Inventory)

Kanban, it's not the newest cocktail sensation, nor is it another new Japanese car. What it is (along with just-in-time and zero inventory) is the buzz word for one of the most effective methods of improving profitability that has been proposed in recent years. The basic premise behind the successful implementation of the Kanban philosophy of inventory management is that —

1. A detailed manufacturing plan or maintenance program exists well into the future which considers such factors as replenishment lead times, material cost, freight cost, inventory carrying cost, costs of a stockout, in addition to known inventories of raw materials.
2. A reliable supplier capable of on time delivery with competitive pricing and superior quality.

From both a customer and a supplier perspective, the ideal situation is to have material arriving in the receiving dock the same day that it can be either invoiced to the customer or applied to a locomotive. Unfortunately, the ideal world does not exist and a prudent materials manager must plan for the unexpected as well as those known demands for material.

In an effort to adopt the Japa-



nese philosophy to our industry, many organizations have created problems by reducing stocks without accurately evaluating the effect that this would have on their operation. Obviously, without added emphasis, being given to forward planning, expediting, quality assurance, or supplier reliability, what is saved by reducing inventories may be more than offset by other expenditures needed to keep units in service. Within the consumer sector of our economy you need only to remember back to this past Christmas season and estimate how many more cabbage patch dolls could have been sold if demand had been more accurately forecast and manufacturing schedules maintained. Profit is profit whether it results from keeping locomotives in service or by reducing operating inventories. A locomotive out of service does not make money for anybody.

Most inventories are established using two factors. Consideration is first given to material whose usage can be fairly well predicted. This "working inventory" is based on projected requirements time—phased over several periods and offset by planned receipts. Assuming a predictable rate of five widgets needed monthly, for example, a schedule of five widgets per month could safely be issued and the replenishment pattern would resemble a classical saw-tooth pattern (Diagram A) for six months.

Notice that at the end of each month, all five units are used in time for the next month's receipt.

Severe problems occur, however, when the planned requirements become more unpredictable. Diagram B illustrates such a condition, which has been observed on a commonly demanded locomotive part.

When sudden peaks or valleys disrupt the normal supply function causing either excess or shortage, added (and sometimes hidden) expenses result from lost revenues or unnecessary carrying costs. Although the cost of maintaining inventory is not cheap (20% of its cost), the cost of not having critical stock could be disastrous by

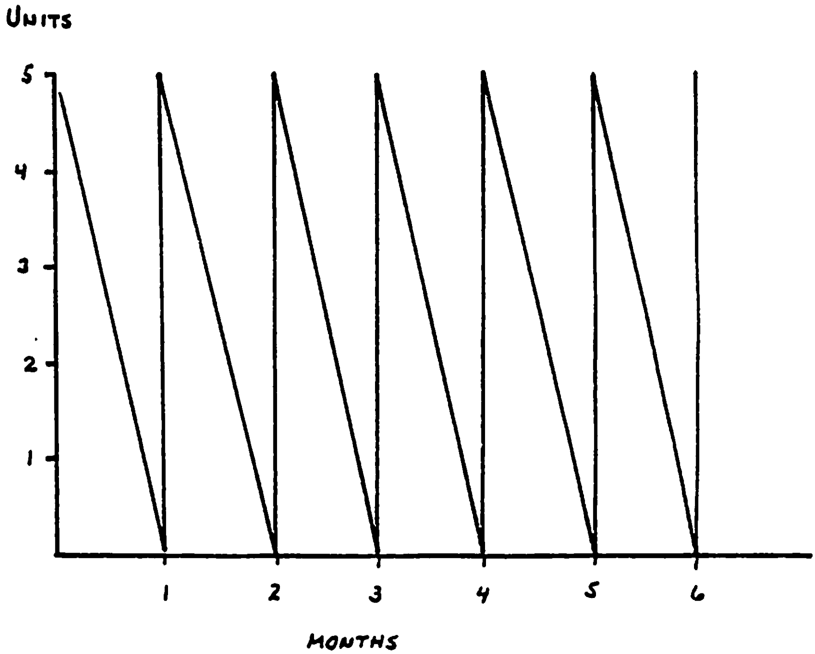


Diagram A

comparison when considering the roughly $500 per day rate for keeping a locomotive out of service.

In recognition of an unpredictable world, most inventories also consider a "safety stock" calculation that is added to the "working" stock to arrive at the total inventory goal for a commodity. The classic inventory depiction of an item over a period of time is detailed as Diagram C.

Safety stocks should seldom be utilized but exist as a cushion against the unexpected as occurred at point "A" on diagram C. In most cases, we would expect safety stock literally to gather dust until needed.

The concept of just-in-time inventory management is to reverse the notion of safety stocks being used to camouflage inaccurate forecasting and emphasize better forecasting in order to minimize safety stocks, just-in-time not just-in-case.

How can this be achieved?

The answer is communication between people.

Each railroad can readily identify commonly sourced items that are required monthly. It should have a good idea of its routine maintenance plans for several months or a year into the future in terms of the number of units being planned for maintenance. Likewise, when maintenance is performed it should be known what components and quantities are "normally" demanded. Such items as cylinder heads, liners, pistons, exhaust valves, bearings, carbon brushes, fuel injectors, ring sets and filter elements are all items subject to prior planning relative to planned maintenance programs. Such requirements, when accurately planned by the Mechanical department, passed to Materials Management, and forwarded to the suppliers can be crucial inputs when planning inventories at all locations.

Diagram B

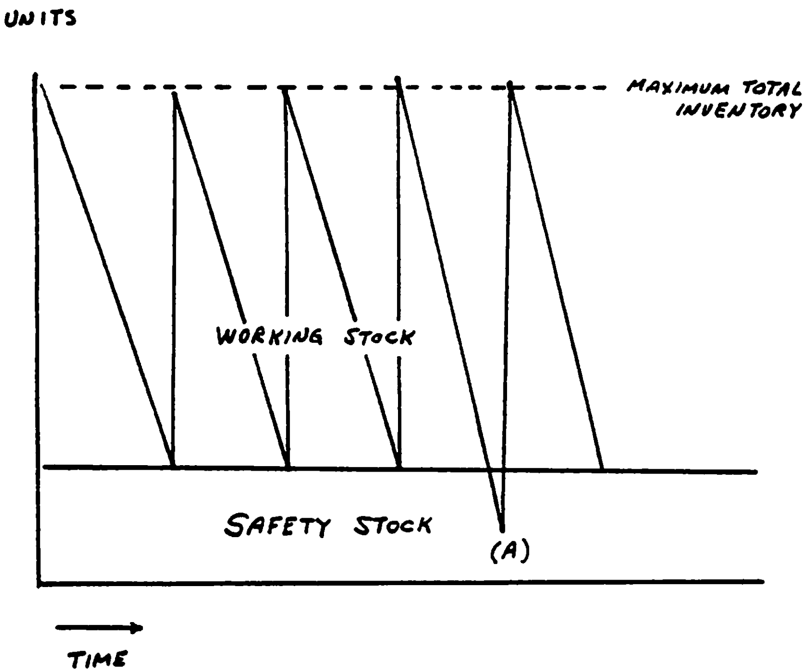


Diagram C

For example, suppliers may forecast railroad demand based on past buying patterns. Varying periods of demand history are analyzed along with other smoothing constants which may give more recognition to current activity. At Electro-Motive, for example, the past 36 months' demand for each item is reviewed monthly but more weight is given to demand within the most recent 4-6 months than the demand which occurred 36 months ago. Based on these empirical data, sales forecasts can be mathematically derived for every part number. In order to enhance the empirical data, it would be highly desirable to compare the statistically generated demand to the customer projected demand for the same items. Any significant variance could then be identified and more detailed analysis could be made.

Consider the following simplified example wherein three railroads have demanded part "Z" each month in the following quantities:

Note that railroad "C" is relatively predictable and a reasonably accurate forecast of demand could be calculated. Railroads A & B,

RAILROAD

	A	B	C	TOTAL
September	20	0	30	50
October	0	0	30	30
November	50	10	30	90
December	70	30	20	120
January 1984	25	0	20	45
February	0	50	30	80
March	30	60	20	110
April	35	40	25	100
May	40	20	30	90
June	0	0	25	25
July	0	10	25	35
August	100	10	25	135
Monthly Average	31	19	26	76
Std. Deviation	±22	±20	± 4	±36

however, provide unique problems and forecasts for these customers would be much more difficult. Likewise, sudden demand changes such as the 100 pieces ordered by "A" in August would run the risk of depleting part, or all, of the inventory and those customers whose buying patterns were regular and predictable may suffer. Assuming that each customer has a fairly good estimate of his monthly needs, then more accurate stock planning could be accomplished and safety stocks could be reduced. On the other hand, unexpected periods of low demand (June - July) create surpluses that increase operating costs.

The same type of planning can be done by the railroad when planning its inventories to support normal maintenance programs. If it is known how many units will be taken out of service weekly/monthly for maintenance, then the total replacement parts requirements can reasonably be estimated and matched against current available stock to develop a time-phased estimate of requirements to send to the supplier. Concentration on a "vital few" items benefits all but changes to the maintenance plan will occur as will emergency situations forcing units out of service. Only past experience and thorough communication will help to minimize the inconveniences caused by these changes.

This type of forward planning need not encompass all stock. Using the Pareto approach to problem-solving, more attention should be given to "vital few" part numbers that are needed routinely versus the "trivial many" items which are sporadically demanded and are relatively inexpensive to stock.

There are certain pitfalls to be aware of when trying to implement a successful purchasing contract system.

Firstly, accurate input must be received from as many using organizations as possible so that all users benefit. In the railroad A-B-C example, if customer "B" was the sole group to provide a forecast, then sudden buying increases by either "A" or "C" would obliterate extra stock which was destined for "B" unless tight controls are placed on the allocated material.

Secondly, the supplier must be dependable. By relying on timely delivery, and reducing safety stocks accordingly, the railroad exposes itself to the serious consequences that occur when scheduled material is not received. Sometimes it is wise to consider dual sourcing of critical items to avoid supplier interruptions resulting from transportation problems, work stoppages or other unforseen disasters that may affect one supplier, and to take advantage of special periodic price concessions when they become available.

When evaluating the accuracy of existing empirical forecasts relative to customer/user provided forecasts, it is important for the supplier to consider (1) What percentage of past demand is attributable to the customer(s) providing

the forecast and (2) How the proposed forecast compares to past demand. Take, for example, an item which sells anywhere between 20-30 pieces monthly. Of this total, most of the sales can be traced to one major customer along with many smaller customers. Assume the following demand history:

	Customer A	All Others	Total Sales
September '83	17	3	20
October	15	10	25
November	16	14	30
December	19	7	26
January '84	27	0	27
February	20	4	24
March	15	9	24
April	16	9	25
May	14	6	20
June	13	8	21
July	20	2	22
August	15	8	23
Total	207	80	287
Monthly Avg.	17	7	24
Std. Deviation	±13	±13	±10

Customer "A" amounts to 72% of the annual demand and unless other information is available a statistical forecast will be calculated which would consider a standard deviation of ± 10 pieces on a total average month of 24 pieces demanded. The standard deviation for either customer "A" or "all others" would be much greater, meaning that either customer's demand (or both acting in unison) could temporarily generate either an excess or shortage condition for inventory goals established using forecasts based on these data. If an inventory could be determined to support only the "other" demand, along with its uncertainties, and then add to this inventory the exact number of pieces required monthly to support customer "A," much of the safety stock needed to support an average month's sale of 24 pieces could be reduced at a saving to both the supplier and railroad.

Such a concept is beneficial to all involved. The supplier can minimize speculation about when an item will sell and thus reduce some of his inventory carrying costs as well as distribution expense needed to transport material among various possible shipping points. The manpower needed for redundant shipping/receiving among part distribution centers could also be minimized. The supplier's sources of raw materials would be better served by also having a more predictable shipping plan without sudden peaks and valleys resulting from unplanned market fluctuations. Reduced inventories would also be experienced by the railroad along with the subsequent savings resulting from minimized processing time experienced prior to when the material is actually needed. But the most obvious benefits are those from minimizing the time that units are out of service pending routine maintenance, meaning profits to the company and dividends to shareholders.

DIESEL MATERIAL CONTROL COMMITTEE

Five-Year Index

Chicago Railroad Diesel Club

We of the Chicago Railroad Diesel Club were again pleased to be hosts to the Locomotive Maintenance Officers Association for their April 2, 1984 Pre-Convention Presentation.

Meetings: We meet on the first Monday of each month except May (1st Friday), 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

Tuesday, September 25, 1984

1:30 P.M.

REPORT OF THE COMMITTEE ON DIESEL MECHANICAL MAINTENANCE

Pre-Convention Presentation: Chicago Railroad Diesel Club

April 2, 1984 Midland Hotel Chicago, IL

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Supervisor Diesel Engine
Union Pacific Railroad
Omaha, NE

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1984 TOPIC:

"WILL TODAY'S NEW TECHNOLOGY SIMPLIFY TOMORROW'S MAINTENANCE?"

PERSONAL HISTORY

A. K. JORDAN

Born in Burly, Idaho, May 3, 1928. He attended public schools at Burley and Heyburn, Idaho, and attended Idaho State College at Pocatello, Idaho.

He began his railroad career October 1949 at Pocatello, Idaho, as Electrician Apprentice. After completing the four-year apprenticeship, he transferred to Nampa, Idaho.

Beginning in 1958 he held various jobs in Idaho, Oregon, Montana and California as Mechanical Foreman, Engine House Foreman, and Electrical Foreman. In 1968 he joined the Chief Mechanical Officer's staff with headquarters in Pocatello, Idaho, and Salt Lake City, Utah. In June of 1973 he was transferred to Omaha as Director of MP&M Power Bureau.

Early 1974, he was appointed to his present position. He has been a member of the LMOA since 1975 and a member of the Diesel Mechanical Committee since 1978.

Married to the former Patricia Maughan, they have three sons and four grandchildren.

His hobbies are fly fishing, hunting, camping and golf.

WILL TODAY'S NEW TECHNOLOGY SIMPLIFY TOMORROW'S MAINTENANCE?

The theme of this year's paper asks the question, "Will today's new technology simplify tomorrow's maintenance?"

By now, most of you have heard about the onboard locomotive microcomputers and sophisticated electronics being introduced by the locomotive builders. What impact will these new technologies have on new locomotive design, and will these technologies simplify and reduce our maintenance practices and costs? To help answer these questions, let's look at some of the innovations to be introduced by the locomotive builders.

A. Mechanical Aspects of New Locomotive Designs

1. G. E. Dash-8 Locomotives

G. E. will introduce five Dash-8 models when full production begins in 1985. Plans include the:

4 axle, 2,300 h.p. B23-8
4 axle, 3,200 h.p. B32-8
6 axle, 3,200 h.p. C32-8
4 axle, 3,900 h.p. B39-8
6 axle, 3,900 h.p. C39-8.

By mid-September this year, G. E. expects to have a total of 23 Dash-8 locomotives operating on our roads — six field test and 17 pre-production locomotives. An additional nine pre-production Dash-8's are slated for later delivery.

Although the Dash-8 will remain fundamentally unchanged mechanically, there are a number of changes to be introduced that will affect the mechanical operation of the locomotive. We will also look at how the microcomputers will impact the locomotive operation.

Cooling Fans: The Dash-8 will have two variable speed cooling fans, each driven by a 60 h.p. AC motor. Both cooling fans will be controlled by the onboard com-

Burlington Northern	3	(field test)	B32-8
Norfolk Southern	2	(field test)	C39-8
ATSF	1	(field test)	B39-8
ATSF	2	(pre-production)	B39-8
Conrail	10	(pre-production)	C32-8
Norfolk Southern	5 of 12	(pre-production)	C39-8
Union Pacific	0 of 2	(pre-production)	C39-8

puters with the ability to deliver only the exact amount of engine cooling required by the engine water temperature.

The cooling fans can operate at 0%, 25%, 50% or 100% of engine speed. The computer will operate one fan at 1/4 speed, followed by the second fan at 1/4 speed or until sufficient engine cooling is obtained. This logic is applied in reverse order as engine cooling needs are reduced. The computer controlled fans will also rotate start up, so not to overuse either fan.

By replacing the engine eddy current clutch with two AC motors and controlling the output of the cooling fans, an average reduction of parasitic load estimated at 30 h.p. in throttle 8, along with a slight increase in fuel economy, is claimed by G. E.

Air Compressor Drive: The Dash-8 will also come equipped with a magnetic particle clutch, which replaces the full time direct drive engine to air compressor coupling. By replacing the direct drive coupling with a clutch, the air compressor will remain shut down while unloaded. G. E estimates this to be 95% of the time and expects extended compressor life, reduced fuel consumption and air compressor maintenance.

Traction Motor Cooling: Although these next items are basically electrical and will probably be covered by other committees, they also reduce the parasitic load on the engine and should be mentioned. A computer controlled traction motor blower on each truck will deliver only the required amount of traction motor cooling. This is accomplished by varying the volume of air into each motor depending on individual traction motor temperatures. G. E. estimates a savings of 25 h.p. over the mechanical driven blowers on the Dash-7.

Dynamic Brake Cooling: Grid cooling is also computer controlled. G. E. has reduced the auxiliary horsepower required for cooling by 60%. The new design DC motor blower permits the engine to run at only the speed required for traction equipment cooling. This change has allowed G. E. to move the braking grids from the radiator compartment, where they were cooled by a mechanical engine drive, to a separate compartment in the auxiliary cab.

Engine Air Filters: The engine secondary air filtration system will

utilize a 12 element paper filter. However, the paper air filter has increased from 36 to 45 inches in length. This change, along with the increase in primary air cleaners from six to eight, should double the paper air filter life.

A four baggy filter arrangement may be used in place of the paper filters.

Dash-8 Operating Factor: Here is an additional list of facts that may be of interest. Did you know? —

That the engine will not load if the door going to the electrical cabinet on the left side of the locomotive is open?

That when you start up a cold engine, the equipment blowers and radiator fans will go to full speed to add some load and help warm up the engine?

That until the cooling water temperature rises above 90°, the engine will only load up to notch 1 RPM and power, even if the throttle is calling for a higher notch?

That until the cooling water temperature rises above 140°, the engine will only load up to notch 3 RPM and power?

That by manual request, the radiator fans can be set to run full speed backwards for one minute to blow debris off of the radiator inlet screens?

And that a display screen mounted in the locomotive cab will provide messages regarding locomotive operating conditions?

Summary: In summary, these new systems introduced by G. E. on the Dash-8 are intended to demand only the required horsepower to operate the locomotive at the performance level required by the engineer. G.E. states that the entire Dash-8 package will give us a 35% reduction in parasitic loads, a 4% increase in fuel economy and an unprecedented 30% increase in reliability over the Dash-7.

In the opening segment of the paper, this committee posed two questions:

1. "What impact will these new technologies have on new locomotive design?"

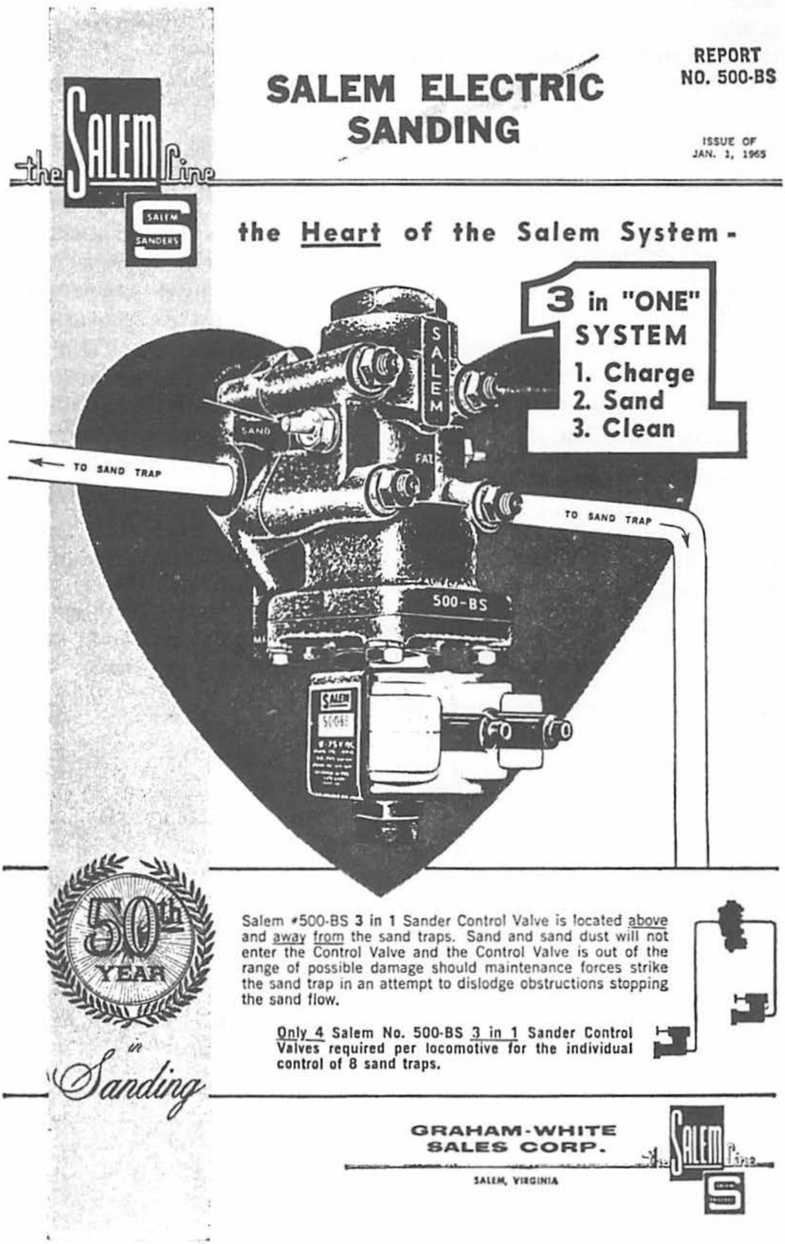
In answering that question, we have summarized a few of the differences between the Dash-7 and Dash-8. Hopefully, we have given you some insight as to how these new technologies are now beginning to impact future locomotive design.

2. We also asked, "Will these new technologies simplify and reduce tomorrow's maintenance practices and costs?"

If G.E.'s claims of a 35% reduction of parasitic loads, a 4% increase in fuel economy and a 30% increase in locomotive reliability over the Dash-7 can be substantiated in actual revenue service, then the answer to that question is a definite yes.

2. Bombardier — HRC Line

While both EMD and GE have opted on entering the computer era on the new production loco-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REPORT NO. 500-BS
ISSUE OF JAN. 1, 1965
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motives, Bombardier has invested their research, development and capital to combine the best features on their existing locomotives with those of their ongoing development program.

The HRC line, High Revenue Capacity/High Reliability, consists of two basic designs. Both a four-axle and six-axle version with three engine options are available:

HR-412, 4 axle, 12 cylinder 2,400 h.p.

HR-416, 4 axle, 16 cylinder 3,200 h.p.

HR-616, 6 axle, 16 cylinder 3,200 - 3,600 h.p.

Engine: The Bombardier 251 engine is not the same Alco 251 engine that many LMOA members may remember from the days when Alco was building locomotives.

Practically every component, with the exception of the crankshaft, bearings and connecting rods, has undergone complete redesign.

As a result of research and field tests on actual locomotives, Bombardier offers 16 cylinder 251 engines at gross horsepower of 3804 HP at AAR conditions. The engine thermal and operating efficiency has been improved by 5.8% of HR-616 first generation versus the M-630 model, and by 5.6% on HR-616 second generation versus HR-616 first generation.

The following improvements have been made to the 251 engines:

Turbocharger: The high capacity model 165 turbocharger with increased efficiency is now standard on all HRC line locomotives. The special features of these turbochargers are:

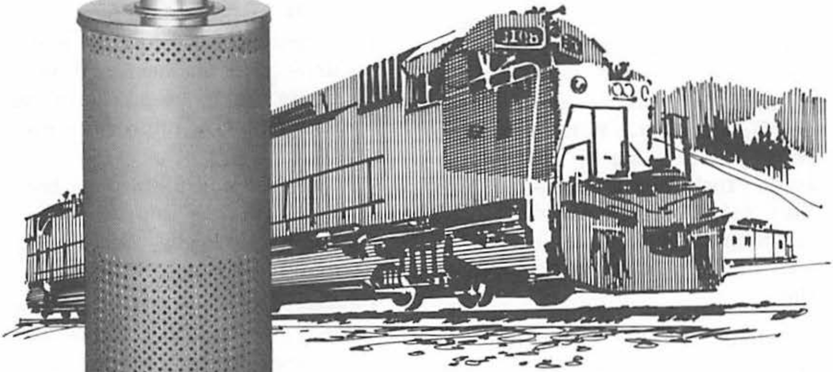
a) Water-cooled fabricated main casing which provides greater resistance against temperature induced cracking.
b) Water-cooled gas inlet casing.
c) Thrust bearings located at the compressor end of rotor where cooler temperatures can be maintained.
d) Turbo disc, blade and nozzle ring are all made with high temperature resistance material having a higher margin of safety in operation.
e) Improved design of all parts to lower stress levels.
f) Turbocharger is fully matched with the engine system, for the required power to obtain maximum fuel efficiency and exhaust temperatures.

Aftercooling:

a. The aftercharger air inlet has been redesigned to reduce aero-dynamic losses.
b. The capacity of the aftercooler has been increased to improve the aftercooler performance.

Camshaft Overlap: The camshaft overlap has been increased from 123° to 140° for improved efficiency.

Fuel Injection Timing: The fuel injection timing has been advanced from 25½° BTDC to 27½ BTDC for improved efficiency.

Timing helix fuel pump has been developed to optimize the injection timing over the noted range.

Pistons: A more efficient combustion chamber design has been achieved through the use of a deep bowl piston which replaces the Mexican hat, flat top and dish top configuration. With the deep bowl piston using a 161° spray angle fuel injection nozzle and 140° valve overlap camshaft, fuel consumption has been reduced as well as lubricating oil contamination.

Cylinder Blocks: Bombardier investigated the cause of cracking in the area of the camshaft bearing attachment. Bombardier undertook and concluded the generation of a finite element computer analysis of the cylinder block stress pattern. This analysis formed the basis for a major redesign of the cylinder block in the camshaft bearing support area.

Water Pump Seal: For many years the water pump seal was a major item of maintenance cost. Considerable development effort has been expended by Bombardier to improve the reliability and durability of the engine water pump seal.

This includes:

a. Improvements in sealing surface, finishes and general redesign of the seal in conjunction with seal suppliers.
b. Flush cooling of the seal and a water circulating device to reduce seal pressure and allow proper flushing of the seal. A kit is now available for the application of flush cooling to existing pump seals.
c. Improved control of the pump drive gear backlash and wear limits have been shown to significantly improve seal life.
d. The free end piping has been redesigned to improve accessibility thereby facilitating maintenance of the pump.

Chassis: The overall operating efficiency of the locomotive has been improved through the optimization of auxiliary equipment designs. This includes the use of more efficient radiator fans; the use of self-ventilated dynamic braking equipment permitting substantial reduction in the size of the traction motor blower; the elimination of filter bleed air requirements through the use of panel filters; and a more efficient engine room pressurization arrangement.

a) **Air Filtration:** The primary inertial filters have been replaced with fiberglass panel type filters.

Bombardier's tests have shown these to be more effective in preventing the ingress of snow, that they are simple to maintain, and that they also save on parasitic loads since there is no need for bleed air.

Because these filters are disposable and adhesive-impregnated, Bombardier feels that they will obtain greater efficiency and econ-

omy than with the permanent washable filters.

This type of filter consists of a permanent, galvanized retaining frame and a disposable glass-fiber media pad.

Information supplied by various railroads shows that the total cost of these filters, installed, is significantly less than the labor, material and overhead costs involved in cleaning and reconditioning washable filters. They offer equal or greater service life than washable filters at the same CFM rating.

b) **Cab Design:** The cab is larger than on earlier narrow body models. The electrical cabinet has been moved back, increasing floor space in the cab by approximately 25 per cent. In addition, new models can have an option of a much smaller control console, eliminating the old-style controls and making the cab even more spacious.

c) **Full Width Car Body:** Another feature of the HRC line locomotive is the availability of a full width car body, sometimes referred to as the "Draper Taper", because of the input from CN Rail in the development of this wide car body and crew comfort cab concept.

Such an arrangement provides for better maintenance in the harsh Canadian winter climate by providing a well lit environment protected from the weather. The car body is equipped with removable side panels to facilitate major overhauls.

This design features a cutaway behind the cab. It permits the engineer expanded rear visibility for a wide car body, and allows full-view inspection of the train even on a slight curve.

Direct access to the engine room allows and encourages "on the road" inspection by the operating crews.

Hinged roof hatches, a characteristic of the wide car body design, facilitate the removal of cylinders and liners. The interior permits maintenance and repairs on all equipment without removing any hoods or covers. Side access doors of road switchers have been retained while outside catwalks have been eliminated.

d) **Optional Winterization Feature — Traction Motor Blower:** This winterization feature should improve the reliability of train operation in cold weather, and most particularly in heavy snow conditions. Equipped with a redesigned blower system, snow entrance into the traction motors will be minimized.

The intake of the blower will have louvres on top, servo controlled, activated by changes in traction motor temperatures. When the temperature rises, the louvres open to admit air. In winter conditions, they will remain closed much of the time. That means a reduced possibility that snow will cause a traction motor ground. Bombardier expects this feature to further reduce the demands on the engine, and in sustained operation, reduce fuel consumption.

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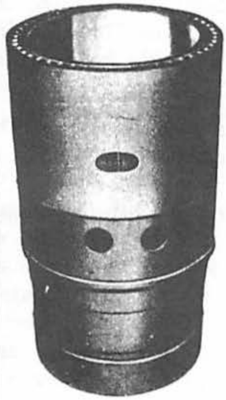

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San Francisco, California 94103
(415) 621-1465

This HR-616 locomotive can be supplied with the standard switcher type car body, or with the full width wide car body.

3. EMD SD50A Locomotive

The EMD SD50A locomotive will include major design changes in every locomotive system. They include the following:

16-710G3 Engine
Microprocessor Electrical Control
AR11 WBA-D18A Generator/Alternator
Traction Motor Blower Movable Inlet Guide Vanes
2-Speed Cooling Fans
D87A Traction Motors
Air Compressor Clutch
Increased Filter Capacity
Radial Dynamic Brake Grids

We will discuss three of these improvements; the 16-710G3 engine, air compressor clutch, and increased filter capacity.

710G3 Engine: The EMD 710G3 engine was designed for greater reliability, extended component life and improved fuel economy. The displacement per cylinder increase from the current 645 in^3 to 710 in^3 is accomplished with a one inch longer stroke over the current 645 series engines while retaining the same cylinder bore. To maintain the same horsepower output, engine speed is reduced to 900 RPM. This lower speed will improve fuel economy and reduce engine component wear. The 710G3 engine also incorporates a larger, high efficiency "G" turbocharger. The injector plunger and bushing diameter was increased to 9/16" for faster fuel delivery.

Overall engine dimensions increase in order to accommodate the longer stroke. The increased length of the engine is due to the larger "G" turbocharger. Other dimensional changes are listed below.

Crankcase steel bore increased by 1"
Piston height increased by 1"
Cylinder liner is 2" longer
Larger camshaft and cam follower
Rear gear train #1 idler increased from 58 to 64 teeth.

The 9/16" injector body nut is a different size than the current 1/2" injector. The injector well in the 710 head is also changed to accommodate the new injector and to prevent installation of the incorrect injector. The 710G3 engine also utilizes a single large water pump.

Air Compressor Clutch: The EMD air compressor clutch is a dry plate type clutch. It is a spring-engaged and air-disengaged clutch. The clutch engaging or disengaging process is controlled by the CCS (Compressor Control Switch). The CCS low pressure setting will cut in the clutch and the CCS high pressure setting will cut out the clutch.

The clutch application will improve locomotive fuel economy approximately 0.8% over a medium duty cycle.

The air compressor clutch has two operating modes:

A. Clutch Engaged
This operating mode will exist when
1. There is no air in the locomotive system
2. There is a requirement for air to be supplied to the locomotive air system
3. The clutch control system fails

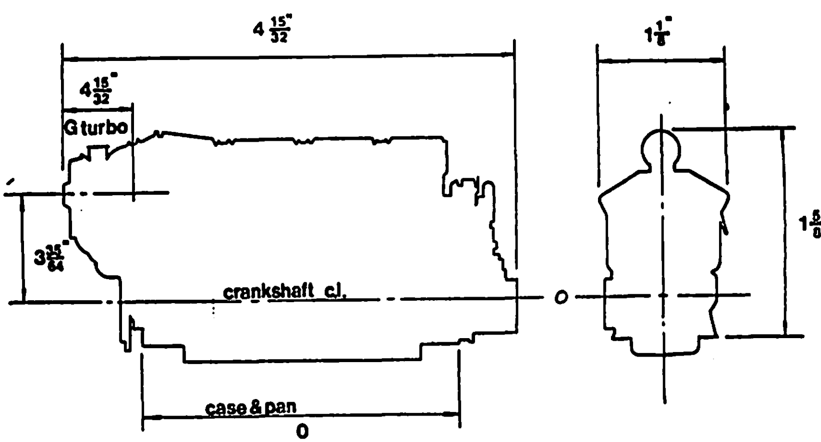
B. Clutch Disengaged
This operating mode will exist only when there is no air required to be supplied to the locomotive air system.

The clutch will become basic on 50 Series locomotives during the second half of 1984. Two designs are currently under evaluation. Laboratory tests have been completed and field testing is currently in progress.

Increased Filter Capacity: To reduce locomotive out-of-service time for scheduled maintenance, a number of new features have been designed into the 50A locomotives including:

— A new 10-element lube oil filter designed for a 91-day filter changeout interval
— A two-element (or optional single large element) primary fuel filter, again for a 91-day filter changeout interval

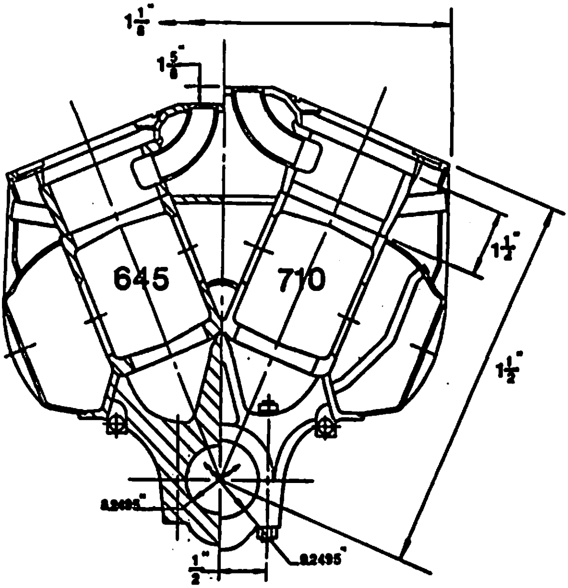
Both of these features have been incorporated into a new equipment rack structure which is also used as the lateral support for the long hood. Troublesome braze-at-assembly oil piping has been eliminated and replaced by "0" ring equipped sub-assemblies to help eliminate oil leaks in the equipment rack area.

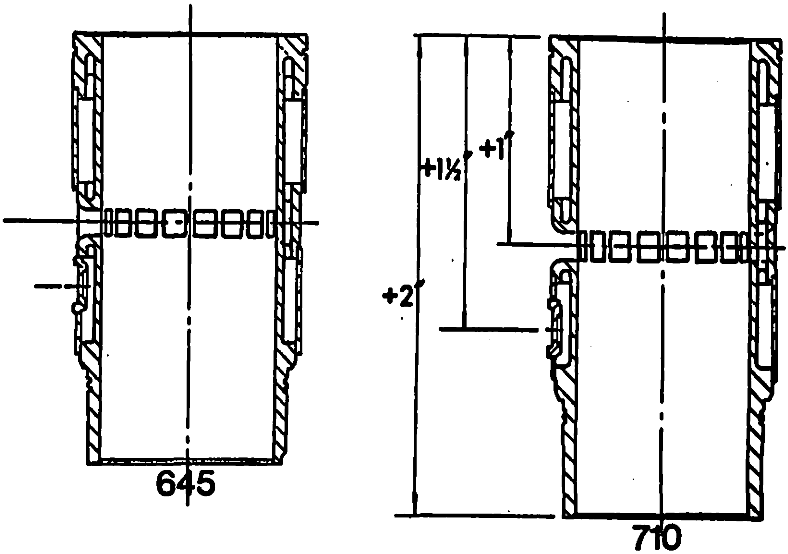


710 ENGINE-DIMENSIONAL INCREASES

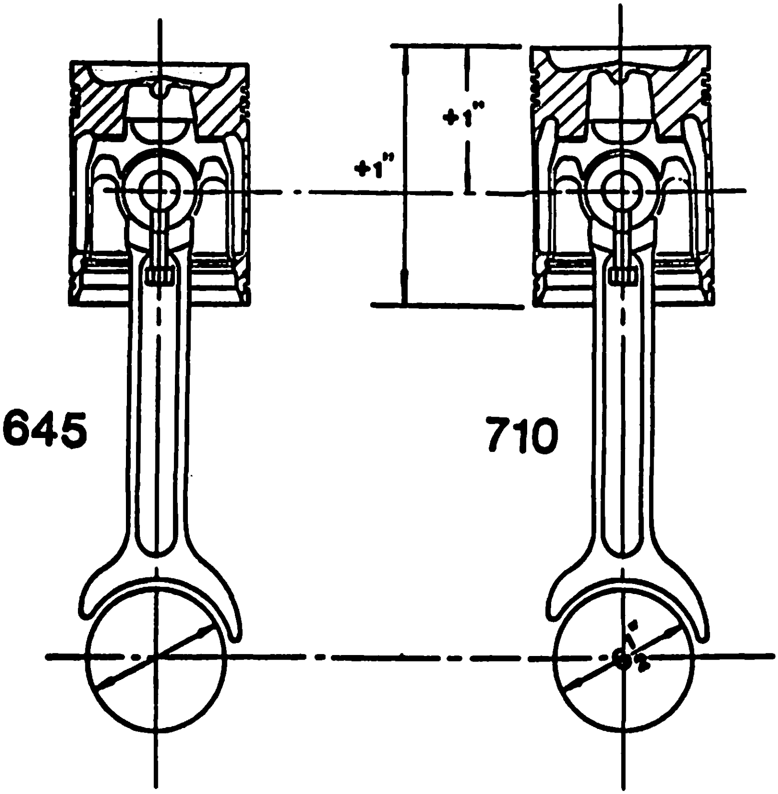
CRANKCASE

dimensional increases

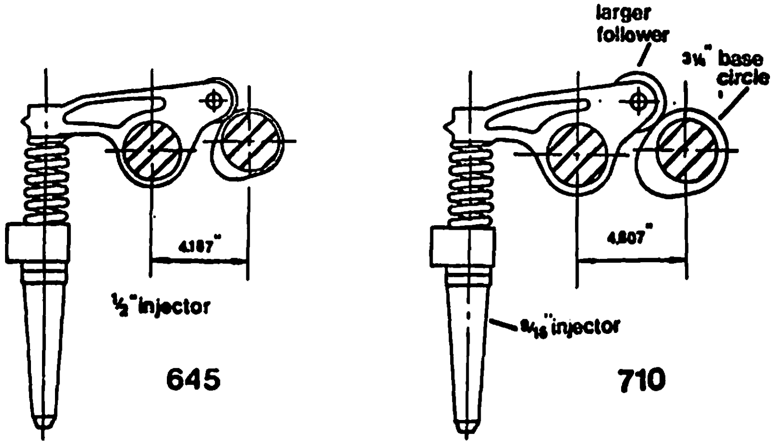


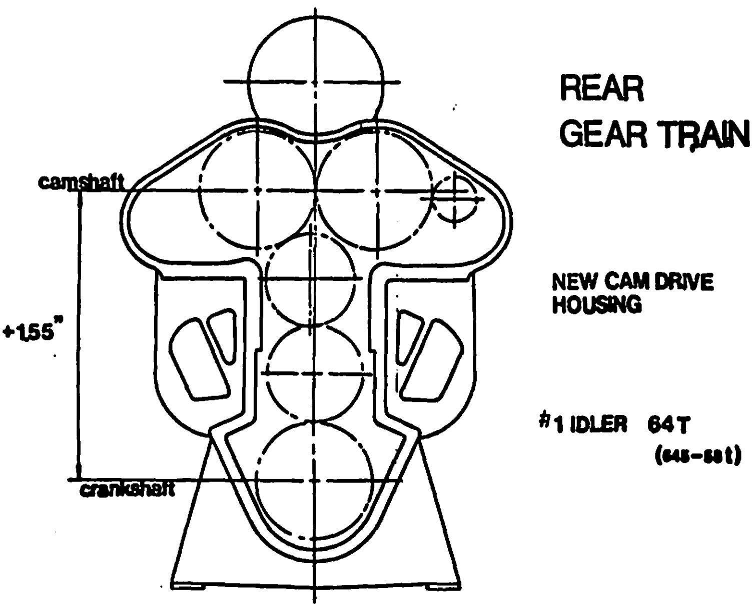


CYLINDER LINER



PISTON & ROD ASSY


larger follower
3¼" base circle
4.187"
½" injector
645
4.607"
injector
710


camshaft
+1.55"
crankshaft
REAR GEAR TRAIN
NEW CAM DRIVE HOUSING
#1 IDLER 64T

B. Maintenance of Locomotive Components

1. EMD Turbocharger

After the turbocharger has been removed from the locomotive and given a preliminary inspection for damage, it is disassembled, cleaned and inspected. Determination should be made at this time if turbocharger can be rebuilt in-house. Rebuilding of the drive gear assembly consists of the following: Inspect planetary gear bushings and thrust washers for wear. Thrust should be minimum .004" to .020" maximum. Install pipe plug in center base of carrier shaft and tighten. Check carrier shaft for stake to prevent snap ring from turning; if required, stake with 1/8" x 1/32" deep groove.

Check carrier bearing support for burrs and general condition. Insert roller bearing retainer ring into carrier bearing support. Press roller bearing into bearing support. Inspect idler gears for burrs and cleanliness of drilled passages. Check oil hole in oil jet pad to be sure it is open. Install oil jet pad with oil hole facing bearing bore in gear support, apply lock plate and bolt, torque to 100 ft lbs and lock bolts with locking tabs.

Insert carrier shaft ball bearing into idler gear support and insert snap ring. Install cover screen on idler gear support, apply bolts, torque to 19 ft lbs and lockwire.

Lubricate inner race of carrier shaft bearing. Place planetary carrier assembly into bearing bore and press into position. Place spacer over carrier shaft. Insert two taper pins from the underside of idler gear support. Lubricate outside diameter of carrier gear pilot and inside diameter of roller bearing inner race and press onto carrier gear. Roller bearing inner races are a matched assembly and should not be interchanged. Place carrier drive gear assembly on carrier shaft, put spacer washers on tapered pins and install drive gear assembly. Apply washers and self locking nuts to taper pins. Place carrier drive gear retainer in position on shaft. Apply retainer bolts, apply thrust washer to retainer plate.

Lubricate inside of idler gear and outside diameter of swivel bearing and press bearing into gear and apply retaining ring. Install pipe plugs over running clutch assembly. Check serial numbers on cam plate retainer and ring gear support. Press in cam plate retainer bearing if removed. Press in ring gear support bearing, remove nicks and burrs from surface of retainer and support. Apply attaching bolts and torque to 21 ft lbs and lockwire. Check clearance between top of camplate retainer and top of bearing; clearance should not exceed .002". Turn assembly over and check other side.

Clutch assembly: Prior to starting assembly of over running clutch, place turbine bearing in freezing container for later assembly into clutch support housing. Remove bolts and complete retainer

from ring gear support. Check holes for wear in ring gear support and install six drive pins. Position camplate in ring gear support so that drilled holes in camplate sockets are counterclockwise in the pockets. If installed clockwise, clutch will not engage. Place camplate retainer on ring gear support with thrust washer dowels in retainer facing out. Using mallet, drive complete retainer onto drive pins and dowels until retainer seats on ring gear support, check drive pins to see that they are flush with retainer. Apply camplate retainer bolts, torque to 21 ft lbs and lockwire. Place a spring cup over each end of roller spring and insert over assembly in the drilled hole of each campocket. Install the rest of the rollers in this manner. Using a protractor, mark the bottom of the support assembly to indicate the alignment point for a bearing oil groove. This will facilitate angular location of the bearing when it is installed. Remove turbine bearing from freezer and insert in support assembly. Align the oil groove in the bearing with the mark on support; be sure that the bearing seats solidly on the shoulder. Install pipe plugs in support. Insert roller retainer into bore of ring gear support and remove spring clips. Install thrust washer on dowels on top of camplate retainer. Oil top of thrust washer and install support assembly in bearing bore and remove roller retainer. Turn support assembly counterclockwise to release the rollers while inserting it in the bore. Turn the complete assembly over. Position thrust washer over dowels in ring gear support. Oil top of thrust washer and install retainer. Apply retainer bolts and torque to 21 ft lbs. Install ring gear on bottom of ring gear support, apply bolts, torque to 38 ft lbs and lockwire. Check end play of support assembly; end play should be within .008" - .030".

Remove burrs from turbine bearing support and clean drilled passages. Insert two guide pins in support assembly of the clutch and place the turbine bearing support in position on clutch, align cutout in bearing support with notch in flange of clutch support assembly. Remove guide pins and apply bolts. Apply gaskets to main housing and install pipe plugs. Install round cover plate over #2 idler stubshaft pilot base. Apply bolts and torque to 36 ft lbs. Inspect and remove burrs on mounting face of turbine bearing support. Install two guide pins in main housing and apply gasket. Install dowels in turbine bearing support. Install bearing support and clutch assembly to main housing. Remove guide pins and apply mounting bolts, torque to 34 ft lbs. Inspect turbine inlet scroll support and remove burrs and nicks. Install guide pins and apply inlet scroll support. Install center closure plate and torque bolts to 34 ft lbs. Insert turbine inlet scroll and remove burrs from mounting surfaces. Install turbine inlet scroll on inlet duct support. Measure distance between top of turbine inlet scroll support to top of the inner flange of scroll, distance should not be less than .122". Install exhaust duct seal ring carrier on inlet scroll, apply bolts and torque to 35 ft lbs. Check seal rings for proper sizing. Seal ring carriers having .215" nominal width ring grooves requiring inserts. Install exhaust duct seal rings and stagger joints.

Assemble upper and lower links to inlet scroll. Leave bolts loose to facilitate assembly of other components.

Install end closure plates and torque bolts to 34 ft lbs. Apply keys into keyways of inlet scroll retainer plate. Apply spiratellic seal to inlet scroll retainer plate. Insert retainer plate into nozzle ring. Apply retainer plate and nozzle assembly on turbine inlet scroll. Apply mounting bolts and torque to 38 ft lbs. Apply turbine wheel shroud and check clearance, maximum allowed is .030". Apply shroud clamping ring and torque to 50-inch pounds. Check nozzle ring to see that it is free and not binding. Check inside diameter of shroud. Measurements should be 14.806" to 14.813" and should not exceed .030" blade tip clearance on radius.

Install compressor journal bearing so that one of the small bearing oil feed holes, to the left of an I.D. oil feed groove is on the turbo vertical centerline. Check bearing for proper seating in housing with .002" between bearing shoulder and support. Install exhaust duct and exhaust diffuser, apply spring clips and torque bolts to 44 ft lbs. Apply spherical seat thrust bearing. Install shaft protector sleeve into heat dam washer and place in position on thrust bearing. Install guide pins into compressor bearing support, apply gasket and compressor seal. Remove guide pins and install bolts, torque to 35 ft lbs.

Install rotating assembly shaft into shaft protector sleeve and lower into compressor assembly. Remove shaft protector sleeve and install thrust washer over turbine wheel shaft and tighten securely with countersunk screws. Using .002" feeler gage, check that there is no clearance under thrust washer. Install impeller spacer. Install a dowel pin in side of impeller seal. Apply impeller seal gasket, apply bolts and torque to 50-inch lbs. Install compressor impeller, retainer and nut, torque impeller nut to 250 ft lbs.

Install two guide pins in the compressor bearing support and apply compressor diffuser. Apply sealant to machine surface of the bearing support and apply compressor scroll over guide pins. Apply bolts and torque to 34 ft lbs.

Compressor section installation: Install two guide pins in the compressor bearing support flange. Center the exhaust duct rear rings on ring carrier. Position the links on turbine inlet scroll to a vertical position. Install compressor section in the turbine section taking care to align the sun gear in the pilot. After the compressor section is seated on the turbine section, apply bolts and torque to 82 ft lbs. Apply exhaust duct bolts and torque to 40 ft lbs.

Install link to clevis bolt. Install shims between clevis mounting pad and the compressor bearing support to remove all clearance around the link bolts. Tighten clevis attaching bolts over shims and torque to 34 ft lbs. Tighten link bolts to 210 ft lbs.

Using a .009 feeler gage, check back edge of impeller to ensure a minimum clearance of .009" between impeller and compressor bearing support. Using a .024" gage, check to ensure the clearance does not exceed maximum clearance of .023".

Mount magnetic dial indicator on housing and check rotor and thrust. End thrust should be between .006" to .020".

Install rotor sweep indicator on end of compressor shaft and check concentric squareness; maximum run-out is .005". Reposition dial indicator to I.D. of impeller cover bore on scroll. Rotate impeller to determine concentricity run-out; maximum is .025".

With turbocharger in horizontal position and dial indicator mounted, lift up on impeller to check available bearing clearance; maximum reading is .015". Return turbo to position so that rotating assembly is vertical. Install two guide pins in scroll impeller lower mounting flange. Mark the leading edge of four equally-spaced impeller vanes 1" from O.D. Apply a piece of dental wax 1/2" x 7/8" to each marked vane inboard of the mark. Chalk or powder the top surface of the wax to prevent sticking, apply .040 shims and impeller cover. Apply three equally-spaced bolts in cover and torque to 34 ft lbs. Remove bolts, cover and shims. Attach magnetically-mounted dial indicator to face of scroll impeller cover. Position the indicator so that the button rests on the wax in direction parallel to the rotor axis. Zero the dial indicator on an unwaxed blade. Rotate impeller and measure wax thickness. The cover clearance should read between .020-.030".

2. G. E. Turbocharger rebuild

Following removal of turbocharger, it is thoroughly inspected.

Remove lockwires, bolts and heat-trapped washers that secure the turbine inlet assembly to the turbine casing. Apply four 1/4"-13 bolts in holes provided in the inlet flange and jack the flange from its fit in the casing. After inlet assembly is removed from casing, the inlet flange is removed from the inlet assembly by unbolting it from the shroud. Discard nuts and bolts. This allows for thorough cleaning of inlet assembly parts. Unless nozzle ring, nose piece or retainer are damaged, they remain as a sub-assembly during cleaning, qualifying and repair. To disassemble the sub-assembly, the retainer bolts are removed and discarded, then the pieces taken apart.

Blower inlet bolts and lockwashers are removed and three 1/2" - 13 bolts are inserted into the holes provided to jack the inlet from its fit in the blower casing. Remove inlet carefully making sure not to damage compressor wheel.

Blower casing bolts and lockwashers are removed and three 1/2" - 13 bolts are inserted into the holes provided in the turbine casing to jack the blower casing from its fit in the turbine casing. Remove blower casing carefully to avoid damage to compressor wheel.

Remove diffuser from blower casing by using a slotted screwdriver to remove six flathead screws. Remove diffuser from casing and handle with care to avoid damaging aluminum mounting surfaces and vanes.

Use a wrench to hold the rotor stud stationary. With a second wrench, remove the rotor locknut and discard. Apply three 5/16"-18 screws in holes provided in rotor cap and evenly jack the cap from the shaft. Remove compressor wheel with a puller and remove key from keyway. For balance purposes, key should remain with shaft.

Remove lockwires and bolts holding blower end seal, and remove seal and discard. Remove thrust collar from rotor and retain as matched assembly.

Turn turbine casing around. Remove turbine disk assembly and shaft, then reassemble rotor assembly to keep parts together.

Remove lockwires and bolts from turbine seal, and pry seal from casing and discard.

Using a brass punch, knock out compressor bearing and discard. Some railroads elect to qualify and reuse some seals and bearings.

Following disassembly, the components are cleaned by means of Proceco glass bead, shot blast or cold parts cleaner.

To reassemble, the machined surfaces of the blower casing and blower inlet are buffed. Inlet, casing and diffuser are checked for cracks or flaws. Blower inlet and diffuser are then bolted to blower casing. Flathead screws used to mount diffuser are secured by diffuser metal into the slot of each screw.

Remove all cleanout covers on the turbine casing, clean all corrosion. Replace covers using new gaskets. Buff machined surfaces and check for cracks.

Apply blanking plates over water inlet and outlet openings, apply 70 PSI water pressure for 20 minutes for leaks. Clean lube oil, seal air, and water passages.

Install blower end bearing in turbine casing with a bearing driver and a hammer. Ensure back of the bearing is fully seated against turbine casing. Turn turbine casing around and install turbine end bearing the same way.

Apply a bead of RTV-106 sealant to turbine seal mounting faces in the turbine casing. Install turbine seal, torque bolts to 95 inch lbs and lockwire.

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Apply a mixture of #10-weight oil and STP to the bore of each bearing, #10-weight oil to the face of each bearing and STP to the rotor shaft. Install turbine disk assembly and shaft carefully, not to damage bearings. Assemble thrust collar on blower end of shaft and align with keyway to exact position as when removed. Apply a bead of RTV-106 sealant to the seal mounting face in the turbine casing. Apply new blower end seal with bolts torqued to 95 inch lbs and lockwire. Apply thin film of STP on shaft and thrust collar face, then apply compressor wheel, aligning keyway to install key. Apply a thin film of STP on rotor cap taper and nut contacting surface of rotor cap. Apply cap and using a new locking nut, torque to 100 ft lbs.

Rotate the rotor to assure it turns freely and measure the lateral by using a dial indicator on rotor cap. There should be .007"-.008" lateral thrust.

Apply Presstite on all machined surfaces of blower casing assembly and turbine casing where the blower casing mounts. While being careful not to hit compressor wheel fins, install blower casing assembly and torque bolts to 75 ft lbs. Check rotor to make sure it turns free. Check clearance between blower inlet and compressor wheel fins. It should be between .034" and .039".

Install turbine inlet assembly. Set a nozzle ring with nose piece into inlet flange and bolt shroud to flange with a torque of 20-25 ft lbs. Apply Presstite to machined mounting surfaces of turbine inlet assembly and turbine casing, install inlet assembly to casing and apply first four bolts in a criss-cross pattern. Check if rotor turns freely. Install remaining bolts, torque to 40 ft lbs and apply stainless steel lockwire to bolts. Check to see if rotor turns.

3. Power Assembly Reclamation and Specifications

Power assemblies are disassembled into four major components: cylinder heads, pistons, liners, and connecting rods. All components are cleaned before any inspection or rework.

Cylinder Heads: The cylinder head is tested for leaks either by hydrostatic or air while submerged in water. The head is magnafluxed for cracks; if cracks are found, OEM guidelines are used to determine whether the head is to be condemned or approved for rework. Valve guides are inspected for wear and replaced when worn beyond limits. Valve seats are cut and ground. Before final assembly, the heads are cleaned to remove metal, grit and other residues left in the machining process.

Pistons: The piston is cleaned under the crown by shotblasting to remove carbon deposits not removed in the initial cleaning. The exterior is examined for scoring and dirt scratches. The dimension of the piston is checked for distortion and rejected if it

does not meet the recommended OEM limits. The ring grooves are checked for wear with a ring gage and are recut to next ring size if found to be beyond wear limits. Some railroads reclaim pistons with ring grooves worn beyond the maximum by applying inserts in the ring grooves or by chrome plating. The piston is checked for cracks using the Magnaflux process. If Magnafluxing is not available, pistons can be checked for cracks by filling them with a solvent, allowing them to stand for a period of time and make a visual inspection for leaks. The final step is the application of a phosphate treatment to restore porosity to the surface for the purpose of oil retention and to reduce scoring during the break-in period.

General Motors Connecting Rods: Fork rods and baskets are not interchangeable since they are line bored as an assembly. Both the fork rod and the basket are stamped with identical serial numbers for matching and identification purposes.

Fork rods are cleaned in accordance with acceptable practices and are checked for surface damage and worn threads in the bolt holes. Serration area is checked for nicks, burrs and cleanliness, upper bearing locating dowels are checked for tightness. Rods are inspected for cracks by Magnaflux. Baskets are inspected for nicks, burrs, and fretting. Any imperfections found must be removed with care to be certain that the diameter of the basket bore is not increased in the process. Rod bore is checked by bolting the basket securely in place and torqued to OEM spec. Bore of the basket is measured at three points 60° apart at each end of the bore. The average dimensions must not exceed specified maximum, and if bore is beyond limits, the rod and basket must be reworked.

The blade and fork rod are inspected for twist, bend, length and bore parallelism. The blade rod slipper is checked for nicks, burrs, heat discoloration and toe-in and toe-out. In checking toe-in and toe-out, a 7.692" diameter mandrel is used. The blade is placed on the mandrel and toe-in is checked by inserting a .007" feeler gage between mandrel and slipper. Toe-out is checked by inserting a .003" feeler gage between mandrel and each end. If the .003" gage can be inserted more than two inches, the rod is reworked.

Rods are scrapped for the following conditions: twisted, bent, out of parallel, damaged or cracked.

Liners: The cylinder liner must be thoroughly cleaned to remove carbon and dirt deposits. Liners are hydrostatic tested for leaks and cracking, and only those found to be serviceable are reworked. The liner is checked for wear and roundness using a bore gage or an inside micrometer. If found to be within the wear limits, the liner is honed for reuse. When liners are worn beyond the standard di-

mensions, then you must consider the alternative of oversizing to .030" or .060" or chrome plating back to standard diameter. In making this decision, it is important to consider inventory cost of oversized piston and ring kits.

4. G. E. Power Assembly Rebuild

This section on G. E. power assembly rebuilding starts with the liners already cleaned, qualified, necessary machining and the head cleaned, qualified, valve seats ground; valve springs and retainers have been applied. The water jackets have only been cleaned.

The jackets are then set upside down on a conveyor line where liner and head seat surfaces are buffed with a 12" Flex-Hone. Exterior gasket surfaces are buffed with a wire wheel.

Liner to jacket seal and head to jacket seal surfaces are measured and must meet the following specifications:

Lower water seal diameter
11.521" to 11.523"
Upper liner seating surface
11.499" to 11.501"
Head wall seating surface
10.499" to 10.501".

All bolt holes are tapped to clean threads for correct torque indication when tightening down the clamp ring. Jackets are placed into an oven capable of heating to 320-350°F requiring approximately two hours when starting with a cold oven.

New clamp ring bolts are treated by dipping in Molydag #210 lubricant thinnned with methyl alcohol, then dried. Seals and gaskets are applied to heads and liners placed upside down on a conveyor that feeds to a press.

One jacket is removed from the oven when temperature of 320-350°F is reached and placed for application of head and liner. An abrasive pad is used to polish head and liner seal surface, and compressed air is used to blow carbon and scale that may have been loosened during heating process. All required seals are placed in the jacket. The head is placed into jacket insuring that the valve springs do not foul the jacket and compression relief valve opening is in line with the opening in the jacket. The lower liner seals and seal area are then lubricated with glycerin; liner is then placed in the jacket. The entire assembly is placed in a press where 40 ton pressure is used to seat the liner and head. An alternate method approved by G. E. is without the press using longer clamp ring bolts and then changing to the standard clamp ring bolts. A pre-set block is used to determine the size of the external square cut seal. Five different square cut "O" ring seals are available, and each is marked with a different colored paint spot requiring a different number of seal retainer rings. These five seals and corresponding retainer rings are found in GEK 61273.

Clamp ring and bolts are then applied and torqued per G. E. specification in a criss-cross pattern.

The power assembly is tested with air pressure set at 45 PSI and submerged in water with rust preventative for a period not less than five minutes.

The Committee is of the opinion that General Electric's recommended 5000 PSI hydraulic test serves no useful purpose, providing the head to liner clearance will not accept the .0015" feeler around the entire circumference of the head to liner fit.

5. Air Compressor

Requalification of air compressor components after the compressor has been disassembled and cleaned:

Crankshaft main bearing journal must be inspected, and diameter checked; minimum diameter is 3.376". Crank pin should not be worn over .0015" out of round or less than 3.496" diameter. Clean oil passage in crankshaft. Shaft size must have a diameter of 3.250 ± .0015". Magnaflux crankshaft for cracks. Crankshafts that are condemned because of wear can be reclaimed by sleeves, plating or welding.

Connecting rod inspection and qualification should include checking the rod for twist, bend, and parallelism. The rod should be Magnifluxed for cracks, and close attention given to cracks in connecting rod cap bolts. Rods and rod caps are line bored and serialized and must be kept together.

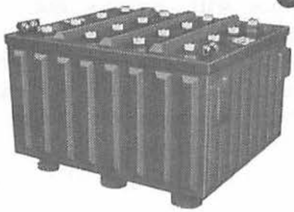
Inspect cylinder for scoring and cracking, check bore diameter for wear. Measure cylinder height if cylinder has been machined to remove cuts and pitting in gasket surface area. When the cylinder has been qualified for service, hone cylinder bore to remove ridges at end of ring travel and to facilitate ring seating.

The cylinder should be honed to a finish of 25 to 40 micro-inches with a crosshatch of 25° to 35°. The proper finish can be checked with a surface indicator. The cylinder must be properly cleaned to remove all metal and grit left by the honing operation. Cylinders worn beyond condemning limits can be oversized, plated or sleeved back to standard dimensions.

Piston inpection and qualification: Ring groove must be square and free from wear ridges, nicks and burrs. Clearance between ring side and groove should not exceed .004". Small areas of scuff marks or scratches can be smoothed or rounded with a file. Do not use emery cloth or carborandum stones. Check piston to liner clearance with feeler gage before applying rings to piston. Minimum clearance of .0035" and maximum of .0080".

Inspect piston pin bushing or bearing for wear by inserting piston pin and checking with feeler gage; replace if worn beyond limits. The piston pin should be replaced if scored, pitted or worn beyond limits.

Air Compressor Heads: Intake and discharge valves are disassembled and valve disc measured



for wear. O. E. M. recommended minimum wear limit is .052" after lapping. Valve discs and seats are lapped and cleaned. Burrs and nicks are removed from the gasket surfaces. Valve bumper is inspected for cracks and wear.

Install spring in bumper, place valve discs on valve seat and assemble valve. Torque clamping bolt or nut to 85 to 95 ft lbs. The complete valve can be checked for leakage by applying air pressure to valve or filling valve with recommended solvent.

Air compressor and head assembly requires the following steps: Inspect head for nicks and cuts on gasket surfaces. Check face or head with straight edge for flatness, maximum allowed is .002". Install valves, clamp cover plate and unloader pistons in head. Torque all bolts and nuts to O.E.M. specifications.

6. Crankcase Reclamation

Crankcase salvage by chrome plating has been used by the railroad industry for over 30 years and has proven to be very successful and cost effective.

EMD crankshafts are classified into two types: "Class C" and "Class D." Class C shafts have in excess of .030" chrome per side up to .060". Class D shafts have .030" per side or less with a minimum of .005".

Class C crankshafts are not recommended in engines over 2500 horsepower. Several railroads use Class C crankshafts only.

This Committee recommends all crankshafts, new or reworked, be equipped with bolt on removeable stub shafts. The two types offered are the EMD style and a slightly different one offered by Chrome Crankshaft.

The General Electric Company has furnished the following recommendations: No chrome plating on the crankshafts of eight-cylinder engines with gross horsepower greater than 1420, 12-cylinder engine with gross horsepower greater than 2150 and 16-cylinder engines with gross horsepower greater than 2750.

For all other applications where chrome plating is acceptable, the minimum thickness should be .005" to maximum .015" per side.

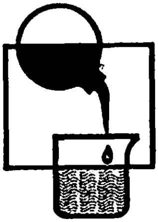
Repair procedures on crankshafts by methods other than chrome plating are still under close scrutiny, as in several cases they have not proved consistently reliable.

This Committee recommends the shot peening of all fillets on all types of crankshafts.

7. Connecting Rod Bearing Problems

This portion of this Committee's paper will deal with the problems associated with EMD, General Electric and Bombardier locomotive engine rods and bearings.

EMD has experienced problems with the 12 and 16-cylinder E3B engines at the slipper surface of the blade rod. The problem has been attributed to the wrist pin



being tapered, causing stress loading on the slipper surface of the upper bearing shell.

EMD has advised the railroad industry of the pin problems on wrist pins manufactured during the period between June 1979 to March 1980 and has offered warranty replacement of any that are failing under this stress condition. The problem associated with wrist pin bearing and the blade rod surface usually does not occur prior to 200,000 to 250,000 miles of service.

The difficulty can be readily identified by inspection of the bearing "fish-back" surface during routine crankcase inspections. Stresses in these areas will ultimately lead to catastrophic failure if not rectified at periodic inspections. The repair necessitates removal of the power assembly to replace the piston pin.

The Committee has no firsthand information other than this particular problem concerning the EMD E3B engine connecting rod bearings. The Committee recommends that EMD's outstanding instructions and maintenance procedures, as well as EMD Pointers, should be followed in routine maintenance practices.

The engines manufactured by Bombardier, based on the previous Alco design, are operating in limited numbers within the continental United States and to this point in time, the Committee knows of no instances of bearing difficulties with this engine. The engine is also manufactured in numbers for export purposes, and there have been no reports at this writing to indicate from any foreign sources, that a problem exists within the connecting rods and bearing area.

The General Electric locomotives equipped with the 7FDL 12 or 16-cylinder engine have experienced, since its inception, an inherent design deficiency with the con rod bearing itself which in many instances has lead to crankshaft failures. The majority of the bearing failures are usually readily definable, such as a lube oil pump failure, overspeed, or some other engine related problem. However, causes for the individual type failure, single spun bearings, are yet to be specifically identified by General Electric.

These types of failures are indicated by the graphs of two major railroads within the United States operating fleet sizes in excess of 400 units. It is interesting to note the parallel between the total crankshaft failures and the con rod bearing failures.

In the past, the railroads and General Electric have defined the individual connecting rod bearing failures as caused by either under torqued or misapplication problems. However, recent investigations indicate that this may not be the primary cause of the failure. If close examination is given to the engine manual as published by General Electric and the tolerances of the crank pin, as well as the rod bore, the maximum toler-

ance specified by General Electric will be exceeded by two thousandths of an inch. Consequently, as a result of these findings, certain railroads are re-evaluating their position on qualifying rod bores on both new and used rod applications.

In addition to the rod bore, proper examination of single spun bearing failures shows they are generally associated with fretting of the rod cap and rod mating surfaces, indicating movement between the rod cap and rod, whether it be from new or reconditioned applications.

General Electric recommends that rods indicating excessive fretting should not be re-used. The railroad industry has asked what is "excessive fretting." General Electric has since come out with publication GET 6345 that defines the problem in more detail to assist the individual in this examination.

The General Electric master rod, as manufactured, has a split line tolerance that does not allow for placement without difficulty in the cap or rod. Consequently, this requires a decision or judgment by the installer. It is critical that the tang and slot side of the bearing be installed flush with the split line surface.

Due to the wide deviation in the split line location specifications relating to possible improper installation, one major railroad has specified the split line on new rods to be within fifteen thousandths of an inch of rod bore center line. As previously indicated, the published specifications relative to crank pin diameters and master rod bores can exceed General Electric's own specifications. The concern for excessive running clearance has prompted one major railroad to undertake a program of pre-assembled rod bore measurements prior to installation of the assembly in the engine. Prior to the engine installation, rod, bearing and cap assemblies are torqued to specifications and measured per General Electric instructions. This railroad has deviated from the tolerances allowed in the General Electric engine publication where all three readings, and not the average of the three readings, must fall within specified bore diameter.

General Electric has developed the grooveless con rod bearing which requires a different rod assembly to the locomotive engine. This assembly, if approached as a retrofit operation, becomes an economic burden on the railroad. At this time, the grooveless bearing appears to have an extended life over the groove bearing; however, this Committee is of the opinion that it is not the ultimate design improvement.

We respectfully suggest that General Electric consider a total redesign of its master rod assembly and bearing to incorporate serrated rod and cap split line mating surface along with doweled bearing and larger cap bolts to eliminate movement between rod cap and master rod. In the opinion of the

Committee, this type of redesign will eliminate the con rod bearing from being the weakest point of the 7FDL engine.

The Committee is also of the opinion that further research and development needs to be done in the area of electron beam welded head or other means of eliminating entry of water into the cylinder, to prevent catastrophic hydraulic failures resulting in crankshaft loss.

8. G. E. Master Connecting Rod Requalification

Every G. E. master connecting rod that enters the shop is requalified to prevent crankshaft and power assembly damage and eventual engine failure. The following procedures were developed through mutual cooperation of G. E. and a major railroad to insure an extended service life of the rods and engine they are applied to.

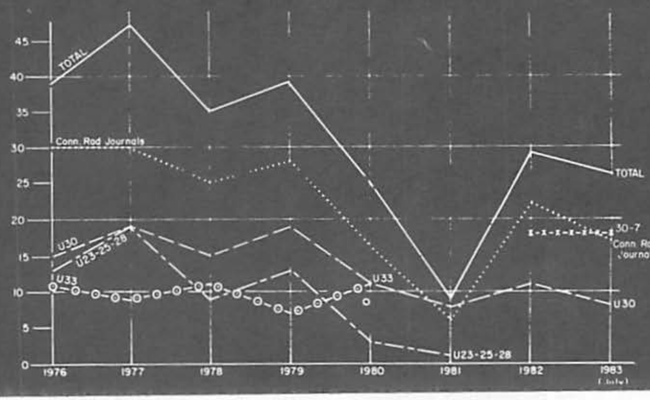
Throughout the stripping, cleaning and requalification steps, all master rods are matched with their caps by the serial number stamped on each.

On old-style connecting rods, G. E. part #117X1030-3, a steel rod 21" long and .495" wide is pushed through the entire length of the oil passage to check for any obstructions and to keep any obviously bent rods from going any further in the requalification process. This is only a rough test that will catch rods with a bend of greater than .010". All new style rods, G. E. part #117X1060-1 that

CRANKSHAFT FAILURES - GENERAL ELECTRIC LOCOMOTIVES

	U23-25-28	U30	U33	TOTAL	Conn. Rod Journals
1976	13	15	11	39	30
1977	19	19	9	47	30
1978	9	15	11	35	25
1979	13	19	7	39	28

	U23-25-28	U30	U33	30-7	TOTAL	Conn. Rod Journals
1980	3	11	11	—	25	16
1981	1	8	—	—	9	6
1982	—	11	—	18	29	22
1983 (July)	—	8	—	18	26	17

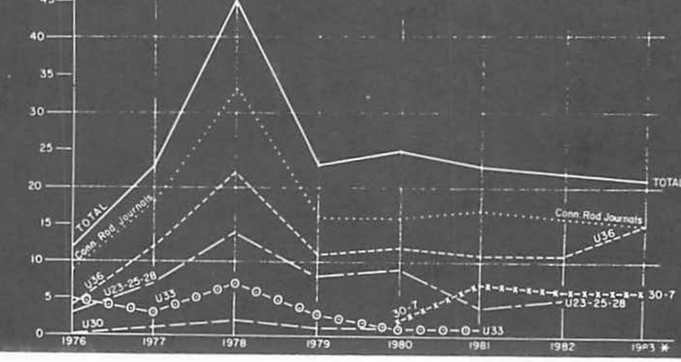


CRANKSHAFT FAILURES - GENERAL ELECTRIC LOCOMOTIVES

	U23-25-28	U30	U33	U36	TOTAL	Conn. Rod Journals
1976	3	—	5	4	12	9
1977	7	1	3	12	23	18
1978	14	2	7	22	45	33
1979	8	1	3	11	23	16

	U23-25-28	U30	U33	U36	C30	TOTAL	Conn. Rod Journals
1980	9	1	1	12	2	25	16
1981	4	—	1	11	7	23	17
1982	5	—	—	11	6	22	16
1983 *	—	—	—	15	6	21	15

* 1983 failures which have been shopped for repairs. As of Jan 10, 1984 there are four locomotives waiting shop that failed in 1983, which are not included in 1983 TOTAL failures.



do not have the straight through oil passage, and rods that pass this test are more critically tested for twists and bends later in the process. Old style rods that do not pass this test are scrapped.

The crankpin bore split line is checked by removing all bearing cap bolts and splitting the halves. A dial indicator that is mounted on a steel bridge is centered on the bearing cap and zeroed. The zeroed dial indicator is then transferred to the rod side of the bore and checked. The difference from the cap half to the rod half must not exceed .032". When the difference exceeds .032", the rod is scrapped. Both ends of the split line are checked to determine any taper from one rod face to the other.

Bearing caps are put back on and torqued to 400-200 ft lb in 100-125 ft lb increments.

Crankpin bore, articulating rod pin bore and piston pin mounting surface are cleaned with a Flex-Hone. Crankpin bore is then sanded with 100 grit silicon carbide sandpaper to remove any burrs or high spots while the other two areas are buffed with a three-inch wire wheel.

Articulating rod pin clearance is checked with a pin calibrated to G. E. specifications, inserted in the bore, and an .008" feeler gauge. (G. E. specifies .0085" as worn clearance limit.) The feeler gauge is inserted from the articulating rod window of the brass bushing at both sides. The feeler gauge must not be able to fit between the pin and the brass bushing.

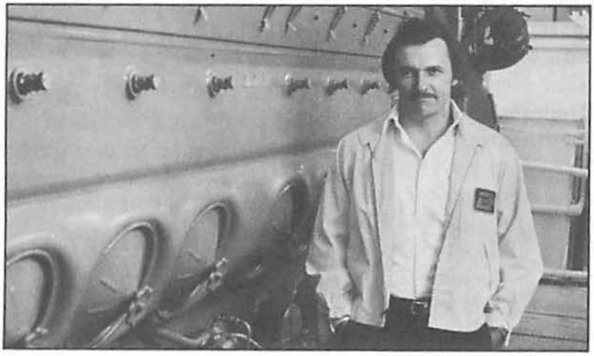
To check the minimum size of the crankpin bore, a 7.8725" mandrel is inserted into the bore. If it does not slide smoothly, the bore is checked for burrs or high spots that are sanded or filed with a fine half-round file, then sanded down. The maximum bore size is checked with the bearing shells inserted later in the process.

An expanding crankpin that is used as a reference point for twist and bend measurements is placed in the crankpin bore and snugged up. A calibrated piston pin is bolted to the rod and torqued to 250 ft lbs. The rod is then placed in a twist and bend test device, G. E. part #147X1502.

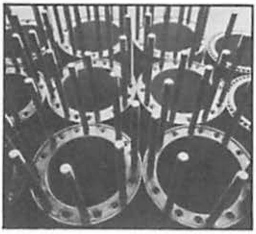
To test for a twisted rod, a .005" feeler gauge is passed between the outermost edges of the piston pin and the machined rails mounted to the frame of the test device. The feeler gauge must not be able to pass through these areas. (G. E. specifies .004" as the maximum allowable deviation from zero.)

To test for bends, there are dial indicators mounted on the test device that touch at each end of the piston pin. Both these dial indicators are set to zero. The rod is then taken out of the test device, turned 180° and placed back in the test device. The total difference between the dial indicators will be how much the rod is bent to one side or the other. Bends less than .005" are allowed. Any rods with a bend of .005" or greater are

"SURE, WE WATCH PRICE, BUT WE BUY ON QUALITY."



Dennis Dorris, Assistant Manager of Operations, Alter Barge Line, Inc.



"We judge price against quality. Chromium Corp. Pattern A liners have worked for us. In comparisons with other liners, cast or chrome, the downtime factor has been reduced to a negligible level.

In one instance on our triple screw vessel, the Beverly Ann, we ran CC Pattern A liners in one engine, cast in another and a competitive chrome in the third. The engine with CC Pattern A used considerably less oil on the average each day. In one month, we saved enough in lube oil costs to compensate for the slightly higher cost of Pattern A liners."

Experience proves CC Pattern A liners cut lube oil consumption, extend liner life and resist the corrosion associated with high-sulphur fuel.

"Since we've begun using Pattern A liners, we've never missed a trip because of a liner failure."

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scrapped. (G. E. specifies bends of up to and including .004" are allowable.)

The bearing cap is removed and the bearings are inserted. On old style connecting rods, only grooved bearings, G. E. part #117X1045-2, can be used because of the straight through oil passage design. New style connecting rods normally use a grooveless upper bearing, G. E. part #117X1050-1. A grooved bearing may be used instead of a grooveless upper bearing, especially in the case of new style connecting rods used with a secondhand crankshaft that has a high spot at the center of each connecting rod journal from previous use of grooved bearings. A grooved bearing is used as a lower bearing regardless of connecting rod oil passage design. To keep field application consistent, it has been chosen to not use grooved bearings in new style connecting rods.

After inserting the bearings, each cap bolt is alternately torqued in 100-125 ft lb increments until 400-425 ft-lb is obtained. This provides the proper "bearing crush."

A hole micrometer is used to check the inside bearing diameter in three planes on each side of the bearing 3/4" from the rod face. The first is taken 90° from the split line. The second and third are taken one inch to 1½" from each side of the split line.

Diameter limits from bearing surface to bearing surface are minimum 7.441" and maximum 7.4453". If any one of the three readings on each side is less than or greater than each respective limit, it must be determined whether it is the bearing shells or the crank pin bore that is in error. The suspect bearings are first removed and the crankpin bore is remeasured. If the bore is all right, a new set of bearing shells is installed and rechecked with the micrometer. When the bore is out of spec, the rod is scrapped. When the problem still exists, the bearings are held under close scrutiny for improper split lines, no "free spread" and alignment tang cut in wrong position.

This completes the process of requalifying the master connecting rod. It is now ready for application of a piston and then to an engine.

MY NAME IS ....

WITH .... COMPANY

I WOULD LIKE TO ASK THE DIESEL MECHANICAL COMMITTEE:

....

....

....

....

MAIL TO: **JOSEPH J. T. KOERNER**
SECRETARY-TREASURER — LMOA
3144 Brereton Court
Huntington, WV 25705

DIESEL MECHANICAL MAINTENANCE

Six-Year Index

1983

Cost Control and Extended Service Life Through Improved Maintenance

1. Leaks: Cooling Water, Lube Oil, Fuel Oil and Air
2. Torquing Recommendations
3. Update on Fuel Efficient Locomotives
4. Radiator Screens
5. Alternate Starter Systems

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

Southwestern Railway Club

Started in 1946, the Southwestern Railway Club this year is celebrating its 38th anniversary.

The organization c)nsists 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 at Kansas City; 4th Thursday of January at Fort Worth; 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.

L. F. SANCHEZ
PRESIDENT
Asst. Superintendent Shops
Atchison, Topeka & Santa Fe Rwy.
Cleburne, TX 76031

R. M. GRIMAILA
SECRETARY-TREASURER
Master Mechanic
Missouri Pacific Railroad
Houston, TX 77028

Tuesday, September 25, 1984

3:30 P.M.

REPORT OF THE COMMITTEE ON SHOP EQUIPMENT

Pre-Convention Presentation: Southwestern Railway Club

April 26, 1984 Camelot Inn Little Rock, AR

J. R. SNOWDEN, Chairman
Shop Engineer
Illinois Central Gulf Railroad
Paducah, KY 42001

VICE CHAIRMAN

M. S. Anderson, Shop Engineer-Mechanical Department, Duluth, Missabe & Iron Range Railroad Company, Proctor, MN 55810

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J. J. Wheelihan	Supvr. Prod. Install.	EMD	LaGrange, IL

1984 TOPIC:

"MORE PRODUCTIVITY AT LOWER COST"

PERSONAL HISTORY
JAMES R. SNOWDEN

Born in Fond Du Lac, Wisconsin, on February 9, 1930. He graduated from high school in 1948, attended the University of Illinois and the University of Wisconsin, after serving four years in the U. S. Air Force.

He joined the Illinois Central Gulf Railroad in February 1977 as an Industrial Engineer at Paducah Shops, Paducah, Kentucky. In September 1981, he was promoted to Shop Engineer and presently serves in that position.

Prior to joining the I. C. G. R. R., he was employed by the Mirro Corporation in Manitowoc, Wisconsin. He served in various engineering, staff and plant management positions during his years with Mirro.

He is married to the former Joy Fredrick, and they have three sons. His hobbies are golf, woodworking and painting.

MORE PRODUCTIVITY AT LOWER COST

Introduction

A key factor in making railroads more profitable is the development of new ways to increase productivity, especially in back shop operations, while at the same time reducing costs.

Automation, robotics, etc. are being applied more and more to railroad shop equipment to help in reducing repair and rebuild costs.

New tools are continually being developed by tool manufacturers and by shop people to aid in reducing costs and increasing productivity.

Our Shop Equipment Paper presents new developments in shop tools and equipment available and in use on railroads to help achieve "More Productivity at Lower Costs."

Following are the subjects presented:

1. Shop Tools:
   A. New Tools
   B. Shop-Made Tools
2. Traction Motor Shop Equipment Up-Date
3. Hazardous Waste Handling and Disposal

NEW TOOLS

Industry is consistently developing new and improved tools. Many of them not only save time and money but improve quality and productivity while also improving safety. Following are several examples.

1. **Baker Armature Tester** (Photo #1)

The Baker Automatic Armature Test System is a fully automated multifunction armature tester per-

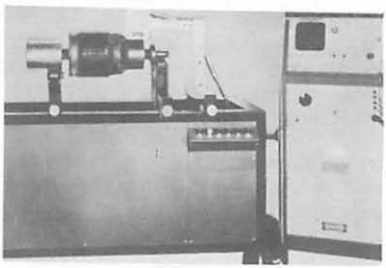


Photo 1

forming three separate and essential tests. The complete system includes:

> A console containing a Model 171 bar-to-bar testing machine, a high current connection integrity tester and a DC hi-pot.
>
> A computer for fully automatic testing, analysis and printout.

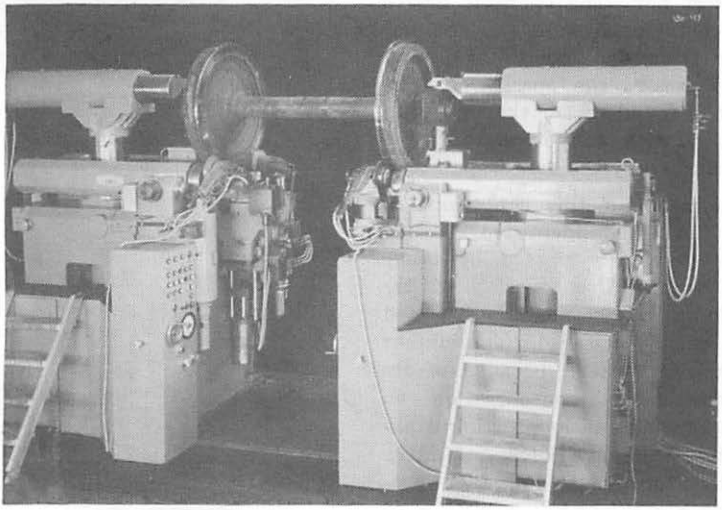
The bar-to-bar test is designed to produce high voltage stress between adjacent bars, turn to turn, and coil to coil as well as stressing ground insulation. The automatic indexer insures testing of each bar and coil by fully rotating the armature. The connection integrity test uses a low voltage 0 to 100 AMP power source to test commutator connections. With a pulsed current of constant value, applied to the work piece, the change in voltage drop is monitored by the computer. Changes in excess of a selected maximum rate of change will cause a failure indication.

The DC hi-pot consists of a 0 to 7500 VDC power supply with a maximum fault current of 5 MA at 7500 VDC. The computer with 5K memory, utilizes a 20 column thermal printer, solid state display and interactive keyboard. All program functions are contained in a non-volatile memory to prevent loss during any power down. System start-up consists of applying power and entering variables for testing. With the armature in place, the computer controller interfaces the various electronic units to the indexer. Following sequential testing, the test data is printed out for armature documentation.

This system is designed with a modular concept in mind and is available without the computer. In this case, the indexer would operate automatically, and the operator would select the mode and observe the values resulting from each test. Also, DC hi-pots and ductors having other ratings can be supplied to suit individual requirements.

The Model 181 may be purchased separately to provide bar-to-bar testing using a hand held contactor. The operator controls the output of the tester and observes the single wave form on the oscilloscope. A stable pattern of consistent amplitude indicates proper connection and sufficient dielectric strength. Any significant decrease in amplitude is a fault indication. This concept originated at GE a number of years ago as a better means to stress each bar with higher energy in order to more closely approximate actual operating conditions of the traction motor armature. Fault locations is made easier because only one channel is presented on the CRO rather than the multiple indications of the surge/span tester. Operator interpretation is simplified, minimizing the need for skilled personnel. Additionally, testing bar-to-bar greatly reduces the transformer effect encountered when surge/span testing, which can transform applied voltages to levels that may damage insulation.

The Model 181 contactor grounds at both ends of the fixture, thereby confining the test and providing



full effect of the applied voltage to the test bar. The operator moves the contactor around the commutator from one bar to the next. As a result, the specific bar in fault is found rather than a group of bars with one or more faults as indicated by the surge/span test.

Operation of this equipment in the field has identified burned coils, previously passed by other type tests. Also, overlap of tig welds on the risers can be detected and readily cleared. The Baker bar-to-bar system, because of its higher energy concentration on each bar and multiple testing capabilities, will save time and labor in armature inspection, thus providing a rapid and sure method of assuring armature integrity and rebuild quality.

2. **Hipotronics AC High Potential Testing Devices** (Photo #2)

For AC high potential testing, Hipotronics manufactures several different models. These instruments are capable of generating applied voltages ranging from 1.5KV to 5KV. They are mounted in a mobile cabinet with two 10" wheels, handle bar and cable holder for easy mobility on the shop floor. They are all equipped with a triple range KV meter and a single range current meter. A burn feature, flashing red light, and a foot pedal are all optional but recommended.

3. **Hipotronics DC High Potential Testing Devices**

For DC high potential testing, Hipotronics manufactures two different models for railroad use. A mobile unit, capable of 10MA at 5000 VDC, incorporates two meters —a triple range KV meter and a triple range current meter. For safety, an output shorting relay with discharge resistor, gravity operated, is standard.

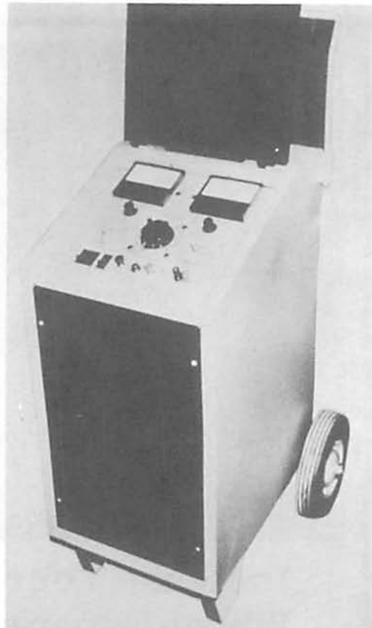


Photo 2

Model AE-B6 Portable Hi-Pot (Photo #3)

Also available is a hand carried unit capable of 6000 VDC at 5MA. This instrument weighs only 20 lbs and can be easily carried on board the locomotive or anywhere in the shop.

5210 Portable Hi-Pot (Photo #4)

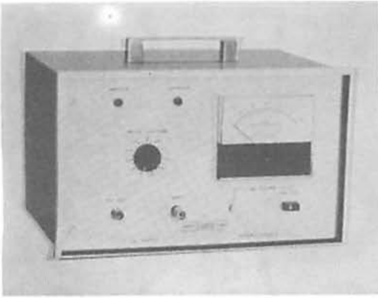


Photo 3

Photo 4

For limited voltage, a battery powered hand carried unit is also available. It weighs only 21 lbs and carries a rating of 1.5 KVDC at 5MA operating, 20 MA short circuit. This instrument can also be carried on board the locomotive and anywhere on the shop floor or yard and has the advantage of not requiring 110VAC input for operation.

4. **IRD Balancer** (Photo #5)

When rotating parts are out-of-balance, the result is vibration.

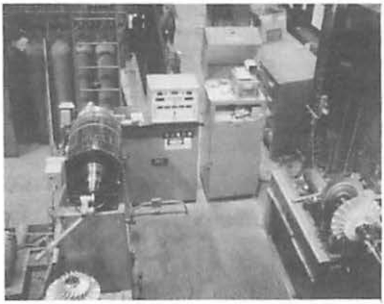


Photo 5

Vibration causes bearing failures and structural damage.

In traction motors, unwanted vibration results in early failure of the armature windings causing grounds and transmitting the vibration to field coils leading to early failure of these components.

It is essential that turbocharger rotors be finely balanced to prolong the bearing life, as bearing failure can lead to catastrophic failure of the turbo. A balancing machine is a valuable asset to any railroad that repairs its traction motors and turbochargers.

One railroad has put together an interesting, efficient combination of an IRD Series 260 Microprocessor Intelligent Balancer, a B50 and a B5 balancing machine. The 260 balancer can either be switched to control the B50 or the B5 machine. Traction motor armatures are balanced on the B50, and turbocharger rotors are balanced on the B5.

The IRD Series 260 Balancer, utilizing the latest microprocessor electronics and techniques, represents a major advancement for maintenance and production balancing. Regardless of rotor complexity, the 260 resolves two-plane dynamic balancing problems in less than a second after receiving the required information.

"Date entry" information is expressed in language familiar to the balancing industry, such as rotor dimensions and configuration and radius dimensions. To balance, the operator simply "touches in" the rotor dimensions, in any sequence, on a clearly labeled and logically arranged front panel.

Here's how easy it is:

1. Enter Rotor configuration and dimensions with a touch.
2. Spin rotor up to desired speed and stop.
3. Make corrections as noted on digital meters.

Corrections are displayed in ounces, grams or static couple and may be quickly converted from one to another with a simple touch. A digital readout displays vibration displacement in mils or microns. The 260 retains the unbalance readout information enabling the operator to select a different type of correction or plane of correction without respinning the rotor. The operator can change rotor configuration or dimensions by simply touching in the new information.

5. **Tesco Cooling System Tester** (Photo #6)

This kit is designed to introduce 20 PSI water pressure to the cooling system via the water tank fill neck. The fill neck pressure fix-

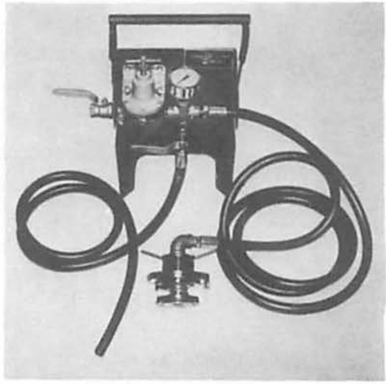


Photo 6

ture is placed on the fill neck in the same way as the locomotive pressure cap, and a spring is then compressed to ensure a positive seal at 20 PSI. Other pressures can be utilized on railway mechanical specification from 0-25 PSI.

House water is connected to the regulator kit with the inlet valve closed, the dump valve closed and the pressure regulator backed off (minimum spring pressure). The inlet valve is then opened and pressure increased by the regulator to 20 PSI. Once the system is charged, the inlet valve is closed. Pressure should be maintained, otherwise a leak in the system is present. Note: sufficient time should be allowed for the system to be charged. If the inlet valve is closed and the gauge immediately reads less than 20 PSI, the system is not charged. Open inlet valve and finish charging system.

If leaks are indicated, a full system inspection is required including

an engine crankcase inspection. Once the test is complete, with the inlet valve closed, back off the pressure regulator to minimum spring pressure and open the dump valve to release the water under pressure. Direct the water away from all personnel by holding and directing the dump hose. Once the guage reads "0" and all flow is stopped, the fill neck pressure fixture can be removed. First reduce the spring pressure and then remove the fixture from the fill neck.

Special Note: This kit was developed to limit the operator's ability to over pressure cooling systems. The pressure regulator provides a range of 0-27 PSI water pressure and the fill neck pressure fixture spring rate was adjusted to relieve at 27 PSI using a new EMD fill neck. The fill neck pressure fixture utilizes a standard fill cap gasket from an EMD or GE fill cap.

Following the completion of testing, two precautions must be observed:

1. Check that the water treatment concentration is correct. The necessary addition of water (probably untreated) will dilute the treatment material. Restore it to proper concentration.
2. Make sure the water level in the system is not left abnormally high. This is especially important with GE locomotives that have dry radiators (no water in them) when cooling is not needed.

While using the Tesco tester system, enough water will be added to fill the radiators with the engine shut down. At completion, drain the system down to "full at engine idle." Otherwise, water will always be in the radiators and the system will run very cold.

6. **New Induction Heater for Pinion Removal (Photos #7 & 8)**

GE and Tesco have designed and built an improved induction heater for traction motor pinion removal. Such a heater is necessary with tighter application of pinions as used on high-tractive effort motors.

The hydraulic pump-off equipment, by itself, is no longer adequate to remove the pinion. The heater and the hydraulic pump-off must be used concurrently.

The specific new feature of this heater is core laminations arranged to concentrate the flux most effectively, keeping it in the pinion and away from the shaft and bearing cap. By doing this, the heater will operate on a relatively low 220 volts and draw less than 200 amperes.

These new heaters are available from GE as Tool Number 41A-239730Pl.

Development testing of the heater and hydraulic pump used together indicates that a gage in the hydraulic line is desireable. If pressure is limited to 15,000 PSI, pinions will not go barrel-shaped in the tapered bore.

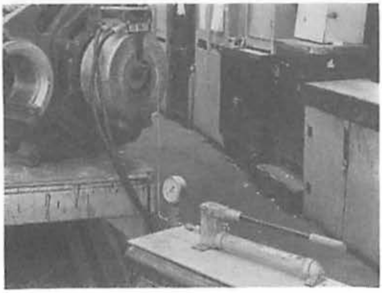


Photo 7

Photo 8

Photo 9

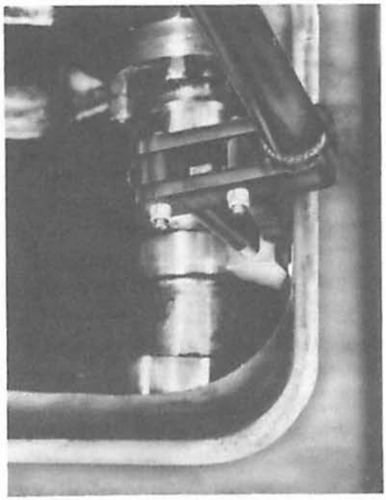


Photo 10

7. **Cam Shaft Fuel Roller Lifter for GE Engines** (Photos #9 & 10)

This tool is designed to ease the job of raising and pinning the cam fuel roller that is required for cam shaft removal. Please note: Cam air and exhaust rollers require removal of the respective push rods in that the valve spring resistance is so great pin shearing will result.

SHOP BUILT TOOLS

Railroads and their shop craftsmen are constantly looking for more efficient and safer ways to perform their jobs. Here are several shop built tools from various railroad craftsmen:

1. **Elliptic Spring Compressor** (Photo #1)

This elliptic spring compressor is used by one railroad to aid shop forces in releasing the tension of elliptic springs on inverted EMD Blomberg truck frames. This expedites the removal of swing hangers and/or elliptical springs without the removal of traction motors.

The device is attached and hooked to the truck frame by placing the arms into the 4-in. diameter fabricated holes of the truck frame. House air is applied to a Duff-Norton jack compressing the sandboard elliptical spring downward allowing for easy removal of bushings and swing hangers. It can now be released to allow for sandboard elliptical spring or bolster removal.

The lifter can also be used as a carrying device to move the truck frame to the turnover device.

The old sandboard compression device necessitated the stripping of components from the truck frame. A job that took an average of six hours now takes only 30 minutes.

2. **Nylatron Jaw Liner Securement Device** (Photo #2)

This is a device one railroad developed for use in the application of nylatron jaw liners on EMD Blomberg trucks to insure the jaw liners are in the proper position for motor and wheel assembly application. The device operates on an eccentric to insure that nylatron liners are butted up tight against the driving faces of the truck frame.

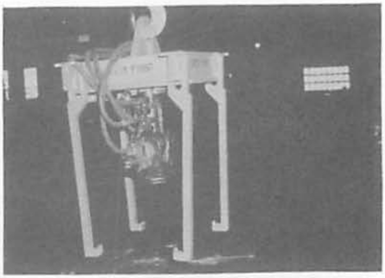


Photo 1

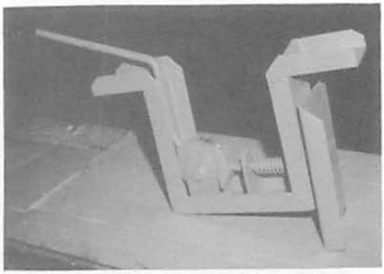


Photo 2

This device also has a self-centering guide to position it in the truck frame. This device will insure that tolerances are within manufacturers specifications.

3. **Tool for Blocking Spring Pack on EMD Locomotives Equipped With Nylatron Pedestal Liners** (Figure #3)

One railroad has developed and recommends the use of this tool which can be shop built, for use as a block between the truck frame pedestal and the journal box spring saddle. Use of this device can eliminate breaking of a Nylatron liner under the pressure exerted by the truck spring pack. They advise that they have had success in using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FIRST ISSUED JAN. 31, 1977	
DATE OF REVISION	

TOOL FOR BLOCKING SPRING PACK ON E M D LOCOMOTIVES EQUIPPED WITH NYLATRON PEDESTAL LINERS

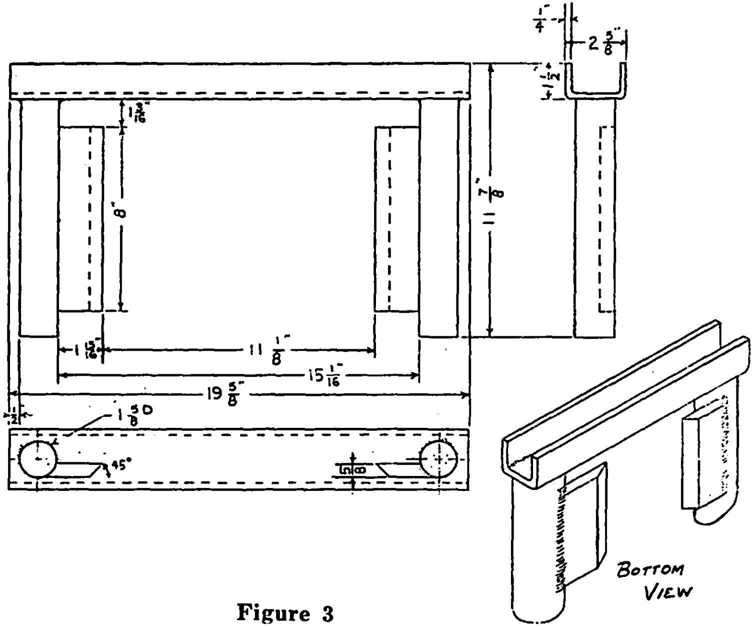
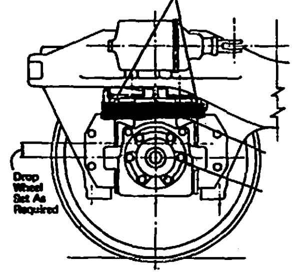


Figure 3

NOTE: Tool inserted to block between truck frame pedestal and spring pack.



CAUTION: A hazardous condition may exist if a Nylatron liner should break under the pressure exerted by the truck spring pack. This tool should be shop made and used whenever it becomes necessary to remove the TM/Wheel Assembly on EMD locomotives equipped with Nylatron pedestal liners.

this tool whenever it becomes necessary to remove the TM/wheel assembly on EMD locomotives equipped with Nylatron pedestal liners.

4. **Positioner for Tig Welding Armatures** (Photo #4)

This shop-built positioner is used for tig welding armatures with automatic indexing to rotate the armature and stop at five bar intervals to avoid overheating of the commutator.

5. **Gauge to Check the Tapered End of Armature Shaft** (Photo #5)

Dial indicators are zero'd on the master and compared to the shaft being checked. Out of round and improper taper can be indicated.

6. **Measuring Jig** (Photo 6#)

This is a measuring jig with two

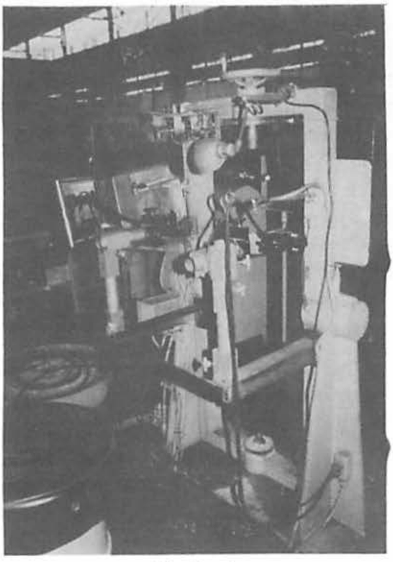


Photo 4

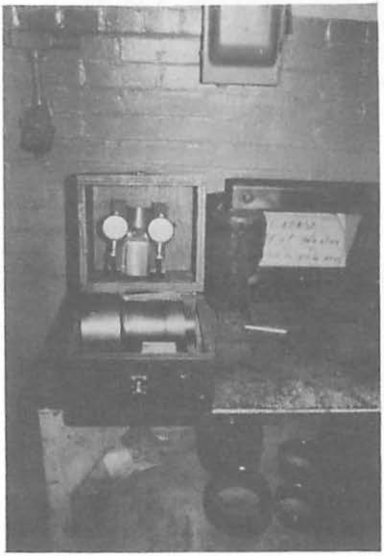


Photo 5

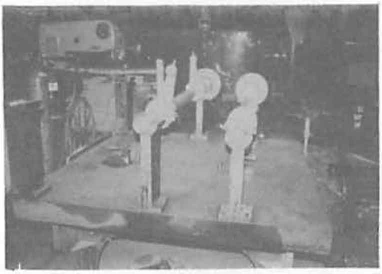


Photo 6

centering shafts with exact distance center to center and at the proper angle to simulate axle and armature center of a traction motor frame.

Frames can be checked for axle bore and armature bore parallel, out of round, and proper center to center. Bearing housing faces can be checked for proper 90° angle to bore center line with dial indicators attached to shafts with clamp holders. Device is checked weekly with a master frame of proper dimensions.

7. **Draft Gear Bushing Inserter/ Remover** (Photos #7 & #8)

One Railroad uses a shop made tool kit for inserting and removing draft gear yoke bushings without the use of a torch or removal of yoke assembly from the locomotive. The kit consists of a hydraulic ram (item 12), several threaded rods and nuts and a variety of collars for pressing the bushings into or out from the yoke casting. Also included is a hydraulic lift table and hydraulic pump.

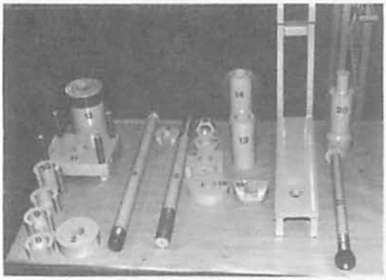


Photo 7

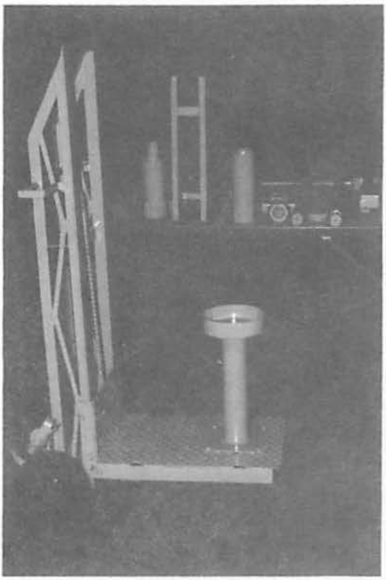


Photo 8

TRACTION MOTOR SHOP EQUIPMENT UPDATE

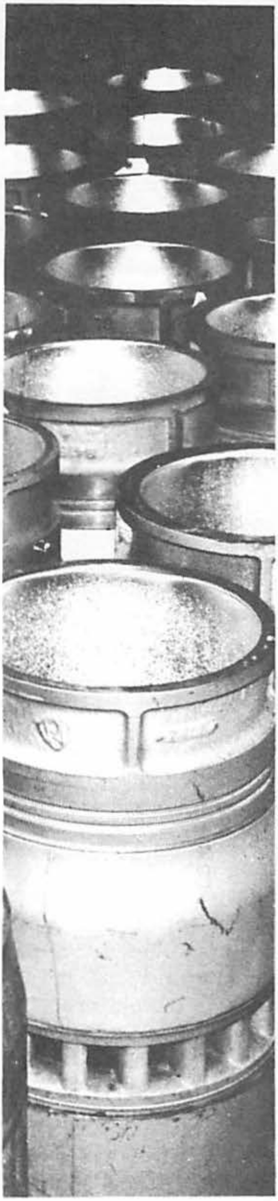
This committee felt it was worth checking into the various methods used by certain railroads to weld up and machine traction motor frames during the traction motor rebuild process.

It may seem difficult to justify the purchase of automated equipment for repair of components of locomotives owing to high machinery cost and the variables of back log and production requirements. However, in the repair of traction motor frames in the conventional way, costs can be sizeable. You must include the cost of handling and the set up time to align the piece to be machined for proper centering and location of bores, splines, and facing fits. And a number of machines are required to do the complete job.

One railroad uses seven different machines to do the machining work on the frame. They are:

An engine lathe used to bore the commutator bearing housing.

A vertical turret lathe to bore the pinion bearing housing.



A milling machine to mill the face and fit of the axle cap and the gear case support arm. A planer to machine suspension lugs on motor frame.

A horizontal mill to machine cap fit and face and keyway.

A horizontal mill to machine armature bore and mill inside and outside face.

A horizontal mill to machine axle bore.

Average production is one and one half frames per eight hour shift.

Another railroad determined that production requirements as well as costs per frame warranted expenditures which include a programmed fully automated Traction Motor Frame Machining Center by Standard Modern Tool Company (Photo 1) and three automated welding machines by Cayuga Manufacturing Corporation (Photo 2) to handle the welding process prior to the frame being machined.

The frame first goes to the face welding station where the axle bore thrust face is welded both on the Commutator end and Pinion end. Then the commutator end inner face and Pinion end outer face is welded.

The frame passes to the bore welding station where the axle bore is welded and then the commutator end armature bore and pinion end armature bore is welded.

The axle caps are removed and the frame then goes to the spline welding station. Here the splines are welded as are the mating faces for the axle caps. This completes the frame welding. The frame is then ready for the Standard Modern machining complex.

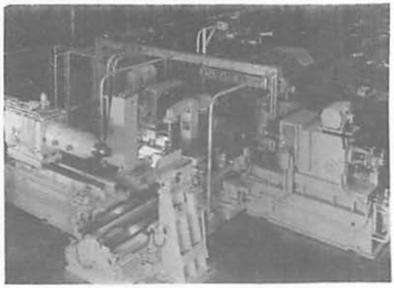


Photo 1

Photo 2

The frame is first properly set up in the frame locater assembly. The frame locater assembly consists of proper hold down devices, plus a spindle with four sets of self centering jaws, one set to locate in the commutator end bore, one set to locate in the pinion end bore, and two sets to locate in the pole piece or pole piece frame pads.

After being properly set up and clamped in place, the machining process is handled through its several steps with very little operator assistance.

See Page 161 For Non Foaming Alkaline Spray Wash
and Hot Tank Cleaner

In the first machining step, a four spindle adjustable milling head is provided to gang mill the frame spline face and axle cap bearing faces in one operation.

The operator then applies the axle caps on the spline face and torques the bolts to the proper finished tightness. The opposed boring heads then automatically bore, chamfer and face the pinion and commutator bores to finish sizes. The boring and facing heads automatically bore, chamfer and face the axle bores to finish sizes. This is usually a rough cut and then a finish cut. The last process is milling of the traction motor gear case support arm.

Manual loading and unloading of the frame is simple. All clamping and jacking forces are controlled by torque mechanisms, providing consistent clamping with minimum distortion of the frame. The finished Product is a frame machined to the proper dimensions that will give many thousands of miles service (Photo 3).

As with all automated operations, there are certain growing pains to get things operating properly. Proper types and sizes of welding wire must be used so the Mig welders will weld at the proper speed to accomplish the job in the required time without malfunctioning.

Photo 3

Proper programming of the machines, as well as trouble shooting, requires skills that may have to be developed or achieved through specialized training. However, in the end it pays off.

This railroad is presently completing four traction motor frames per eight-hour shift, and the number will likely increase as all concerned become more familiar with the operation. This machining operation with the Standard Modern complex requires only one operator compared to many operators required in the first example. It will handle either GE or EMD frames with minor changes.

The precision work done by this machining complex, which is capable of precise repeatability, will certainly pay off in longer life and more dependable performance of the traction motors.

HAZARDOUS WASTE HANDLING AND DISPOSAL

Federal regulations on hazardous wastes, which the railroad industry must understand and comply with, are the result of the Resource Conservation and Recovery Act (RCRA), passed by Congress in 1976. This legislation mandated that the Environmental Protection Agency develop a full regulatory

framework for implementation of the Statute, a task that took nearly six years.

Prior to RCRA, much progress had been made toward control of pollution of the air and surface water, principally through the Clean Air Act and The Clean Water Act. But these laws did not adequately address the ultimate disposal of pollutants that were required to be removed from industrial air emissions and water discharges. That is, there was no assurance that environmentally sound disposal of the objectionable materials would follow. RCRA was intended to cover this area and was principally aimed at protection of groundwater through control over solid waste disposal.

We here review the elements of the RCRA regulations as developed by the EPA, recognizing the typical wastes generated in railroad shops and the proper storage, handling and disposal procedures required. Finally, some methods of minimizing disposal costs of these wastes will be shown.

The federal regulations encourage State programs to deal with hazardous wastes, and various states have developed regulations that are sometimes more stringent than the federal code. Only the federal regulations will be addressed here.

Regulation

The federal concept of hazardous waste management is divided into five major categories as outlined below:

Federal Hazardous Waste Management Through EPA Guidelines

I. Classification of Hazardous Wastes

- A. Must first be classified as solid waste
- B. Must meet at least one of the following
  1. waste explicitly listed by EPA as hazardous
  2. waste exhibits one or more of the following characteristics
     - a. ignitability
     - b. corrosivity
     - c. reactivity
     - d. toxicity

II. Cradle-to-Grave Manifest System

- A. Means to trace waste movements
- B. Generator has responsibility for proper disposal

III. Standards for Generators, Transporters and Treatment/Storage/Disposal Facilities (TSDF)

- A. Generator responsibilities
  1. waste evaluation and permit
  2. packaging, labeling containers
  3. record keeping, permits
- B. Transporting responsibility
  1. spill reporting, record keeping
- C. TSDF responsibilities
  1. groundwater monitoring
  2. new construction—liners/leachate collection

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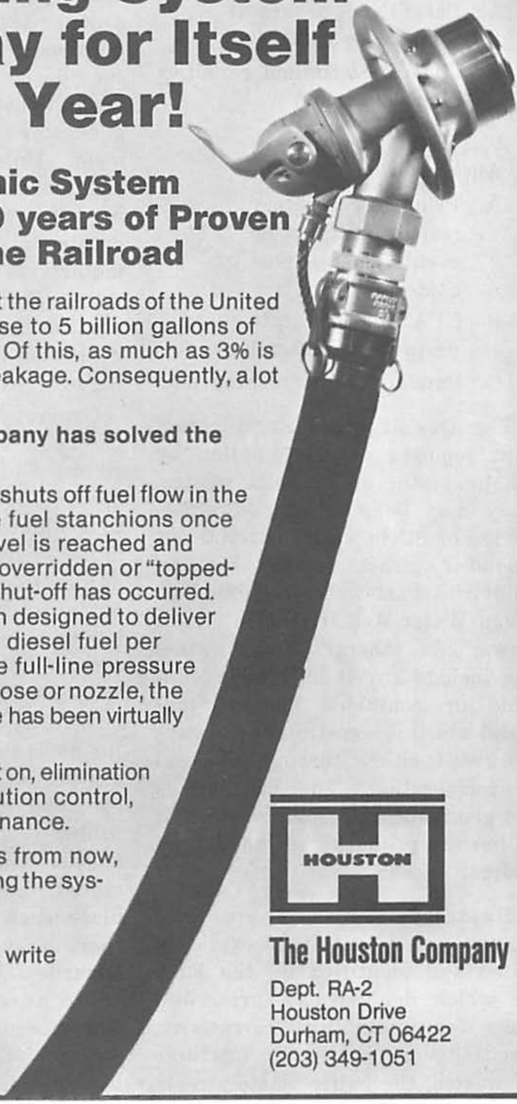

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3. record keeping, contingency and closure plans, permits

IV. Enforcement of Standards

A. Permitting program/ compliance orders

B. Civil fine/criminal penalties (imprisonment)

V. State Program Authorization

A. Primary regulatory responsibility to be eventually assumed by States

B. EPA to assist state program qualification

C. Funding for state programs

The area of waste classification first requires a determination by the generator of its solid wastes. They may be garbage, refuse, sludge or other waste material not excluded (such as domestic sewage, industrial wastewater regulated by Clean Water Act, irrigation return flows, and others). Solid wastes can include any solid, liquid, semisolid or contained gaseous material which is sometimes or always discarded either through disposal or incineration. The material is not classified as a solid waste if it is burned primarily as an energy source.

Hazardous wastes are solid wastes which are either explicitly listed and identified by the EPA or which don't pass prescribed tests for ignitability, corrosivity, reactivity or toxicity. In mixtures of wastes, the entire waste stream is hazardous if it contains the slightest amount of any listed hazardous waste.

The cradle-to-grave manifest concept requires generators of hazardous waste to provide copies of manifests to the transporter and the designated disposal facility, which should return a copy to the generator upon receipt of the shipment. Unless the generator is so notified that the hazardous waste is delivered to the disposal site within 35 days he must begin an inquiry into the status of the shipment. If delivery to that site is not confirmed within 45 days, the generator is to file an "Exception Report" with the EPA.

Generators, transporters and disposers have clearly defined responsibilities in overall waste management. The generator's first job is to evaluate his wastes and determine whether any are hazardous, as described earlier. If so, he requires an EPA identification number to be entered on manifests for off site shipment of wastes. So long as he does not accumulate hazardous wastes on his property for more than 90 days he is not operating a storage facility. However, he must keep materials in proper containers labeled "Hazardous Waste" dated when first stored, follow facility related regulations and maintain records. Further, he must train personnel in hazardous waste handling and develop a contingency plan. If he does accumulate hazardous wastes for more than 90 days he requires a permit for operation of a storage

facility and is subject to more detailed and stringent requirements.

Transporters must also have an EPA identification number, follow all procedures for the manifest system, and maintain records. The transporter is responsible for delivery of the waste to the designated disposal facility and in case of spillage must notify authorities and take action to protect human health and the environment.

Owners and operators of treatment, storage and disposal facilities face much more detailed and complex regulations than generators or transporters because the ultimate disposal is the main concern of waste management. Briefly the regulations require monitoring of groundwater and remedial action in case of contamination. Construction of new TSDF's must include liners and leachate systems to minimize the chance of groundwater pollution. All facilities must record all wastes received, prepare emergency contingency plans and closure plans.

Enforcement of the regulations is accomplished through permit requirements and the power of the EPA to issue compliance orders. Further, the agency can pursue civil action in federal district court if necessary. Criminal penalties including fines and imprisonment are provided in the law for transporting hazardous waste to a facility that does not have a permit or for practices which place another person in imminent danger of death or serious bodily injury.

The EPA is directed to assist in the development of state programs under one section of the law. The state programs would then become responsible for permit handling and other regulatory functions.

Hazardous Waste Management In Railway Shops

A recommended approach to Hazardous Waste Management is:

1. Identify hazardous waste streams.
2. Take immediate steps to comply with applicable storage, disposal, training and facility requirements.
3. Evaluate sources of hazardous wastes and determine whether total costs of those wastes, i.e., initial purchase cost of chemical plus disposal cost, might justify a different process generating less hazardous waste.
4. Investigate cost effective methods to minimize volume of hazardous wastes.
5. Continue policing of waste program to ensure continued compliance.

Waste typically generated in railroad shops and classified as hazardous might include:

1. Sludges from parts cleaning tanks or washers.
2. Strong acids or caustics from batteries or alkalai solvents.
3. Paint solvents, strippers, varnishes and residue.
4. Trichloroethylene and other chlorinated hydrocarbon solvents.

These wastes and others which may be identified through sampling, and laboratory analysis must be collected and placed in DOT approved barrels in the usual case of off-site disposal. The barrels are to be labeled on opposite sides and on top using labels which list the name and address of generator and the manifest number along with the statement: "Hazardous Waste — Federal Law Prohibits Improper Disposal. If found contact the nearest police or public safety authority or the U. S. Environmental Protection Agency."

Storage of waste barrels should be with attention to compatibility of the various wastes in the event of accidental spillage and mixing. Also certain facility requirements such as signs, fire extinguishers, spill containment and security must be followed.

After evaluating sources and processes responsible for existing hazardous waste streams and making any cost effective changes which eliminate wastes, the remaining streams might be reduced through dewatering in the case of sludges from parts cleaning operations. Depending upon the volume of sludge generated, dewatering equipment may be justified as per barrel disposal costs can range from $100 to $300, depending in turn on contents, location and market conditions.

Most commercially available dewatering equipment falls into one of three design-type categories:

1. Plate-type filter press
2. Belt-type filter press
3. Centrifuge

The plate-type filter press is constructed of alternate plate and filter chambers stacked horizontally in a frame equipped with a press, pump and controls. The plates have a center inlet hole and four corner outlet holes to allow the slurry to enter (center) and filtrate to exit (corners). Each plate seals against the adjacent plate by means of rubber grommet seals at the holes.

Operation requires first pressing the plate stack together to seal. Then the slurry is pumped through the center inlet hole allowing dispersion into the many filter chambers until full. Filtrate exits through corner plate passages. When unit is full the press is released allowing plates to separate and the dry sludge drops to a bin below.

Photo 1 shows a plate-type press manufactured by Rittershaus and Blecher.

Belt presses distribute slurry on a filtration belt which later approaches a second belt above. As the two belts join, the slurry is compressed and further compressed when the upper and lower belts wrap around a series of rollers, finally separating again to deposit the dried sludge in a chute.

Centrifugal solid-liquid separators incorporate a mesh drum which spins the water from the slurry. One design has a vertical axis basket with slurry fed in at the bottom. Solids settle against the wall and the filtrate overflows the top of the basket and discharges. When the unit is full, the skimming cycle begins. Blades begin shaving the solids from the still rotating basket allowing the material to fall through the open bottom.

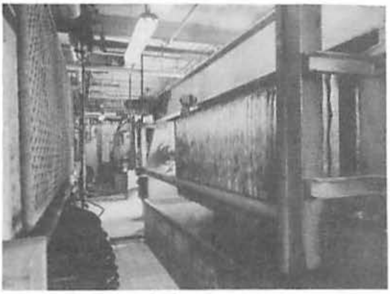

Photo 1

Photo 2 shows a horizontal design of centrifugal separator manufactured by Bird Machine Co.

There are many varieties of design in each of the categories described and many sizes and capacities to choose from. Waste processing equipment of this type can usually be cost justified through savings in disposal costs.

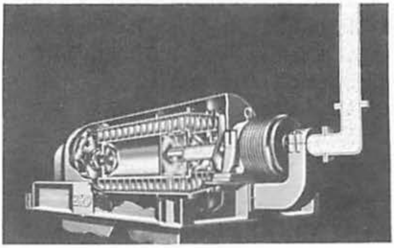

Photo 2

SHOP EQUIPMENT

Five-Year Index

1983

Training and Tools Will Do The Job

1. Locomotive Maintenance Using a Production Line Process
2. Shop Tools to Increase Productivity and Improve Quality
3. Dynamic On-Line Performance of Locomotives Without On-Board Tele-Metering
4. Management in Action
5. New GE Training Center
6. Welding Qualifications

1982

Quality Maintenance Through Modern Tools

1. Tools
2. Rebuild line for EMD turbochargers
3. Air brake equipment line
4. Industrial robots
5. Automated machines
6. Safety related items and equipment

1981

1. Training Aids
2. Testing Devices Inspired by New FRA Laws
3. Tools and Training for Productivity
4. Changes to Shop Facilities Required by Newly Adopted EPA & OSHA Regulations
5. Tour Through Conrail Altoona Shop
6. Supply/Service Facilities
7. GE Assembly Shop

1980

New Tools for a New Decade

1. Traction Motor Lines
   a. Update on traction motor shop equipment
   b. Traction Motor Basics — Southern
2. Fuel Saving thru Security and Reclamation
3. Wheel Machinery, Automated for Diesel Wheels
4. Governor and Injector Room Fuel Savings
5. New Developments in Tooling
6. Locomotive Running Repair Shop
7. Sulzer Diesel Engine — New Tools

1979

It Ain't Just the Same Old Tools

1. New Facets in Locomotive Journal Box Repairs
2. Update & Revaluation of Power Assembly Repair Lines
3. New Concepts in Tools
4. Update on Wheel Truing
5. Concepts in Streamlining Ready Tracks for Locomotives
6. Update Locomotive Cleaning and Washing Equipment
7. Micro Processor — Application for Tooling (Machines)

COMMITTEE ON DIESEL ELECTRICAL MAINTENANCE

PRE-CONVENTION PRESENTATION, KANSAS CITY

GOLD BUFFET RESTAURANT, APRIL 10, 1984

Railroaders and supplymen were pleased to be hosts to the Locomotive Maintenance Officers Association Committee on Diesel Electrical Maintenance for their Pre-Convention presentation at Kansas City on April 10, 1984.

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

T. D. MASON
Chief Mechanical Officer
Atchison, Topeka & Santa Fe Rwy.
Chicago, IL 60604

Wednesday, September 26, 1984

9:00 A.M.

REPORT OF THE COMMITTEE ON DIESEL ELECTRICAL MAINTENANCE

Pre-Convention Presentation: Kansas City, MO

April 10, 1984 Gold Buffet Kansas City, MO

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Engineer Design Mechanical
Union Pacific Railroad
Omaha, NE 68179

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K. M. Watkins	Director of MP Engineering	Amtrak	Washington, DC

1984 TOPIC:

"ELECTRICAL TECHNOLOGY TO IMPROVE PERFORMANCE"

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.

ELECTRICAL TECHNOLOGY TO IMPROVE PERFORMANCE

1. On-Board Diagnostics
   - A. EMD's New Microprocessor Diagnostic System ...... D. J. Kozak
   - B. GE's New Dash-8 Microprocessor Diagnostic System .... D. I. Smith
   - C. Harris "Probe" Diagnostic System for Diesel Locomotives .. K. Watkins
2. GE's CATS (Computer Aided Troubleshooting System) .... D. I. Smith
3. Fuel Conservation Through Electrical Modifications
   - A. Low Idle
   - B. Two Speed Braking
   - C. Eddy Current Clutch .... J. Nixon (GE) R. Gill (EMD)
4. Performance of Locomotives After Storage .... T. D. Lemons

THE ELECTRO-MOTIVE DISPLAY/DIAGNOSTIC COMPUTER SYSTEM

Introduction

The Electro-Motive "50A" Series microprocessor - controlled locomotive is equipped with a Diagnostic/Display computer system. This system is a technically advanced maintenance tool, an Event and Performance Recorder that will provide improved locomotive availability.

The Display/Diagnostic computer system consists of the Display CPU, Arithmetic/Digital Processor module, Archive module, Common Memory module, and Display/Diagnostics panel. For our discussion we will focus in on the operation of the Display/Diagnostics system.

The Diagnostic-Display system offers the following functions:

1. To serve as an on-line diagnostic system that monitors all computer and locomotive functions.
2. To record failures and associated information at the time of failure for later analysis.

3. To serve as a multiple test meter, displaying selected signals.
4. To accumulate and record locomotive running data such as KW hours, duty cycle and mileage.
5. To serve as an interactive trouble-shooting device in locating failures.
6. To accomodate transducer input from mechanical systems, as they become available, to expand mechanical system analysis.
7. To replace, expand, and enhance locomotive fault lights and annunciators for the locomotive operating crew.
8. To serve as an input device for various test and reset functions reducing the number of switches required and centralizing the operation of these functions.

See photo 1.

System Operation

The Display/Diagnostics system panel is located in the center door of the electrical cabinet. During normal road operating conditions, the display screen is blank as shown.

Automatic/Immediate Display

In the past, if a failure was detected and the information was useful to the operating crew, a light on the Engine Control Panel would indicate the failure. Now, the message will appear on the display screen.

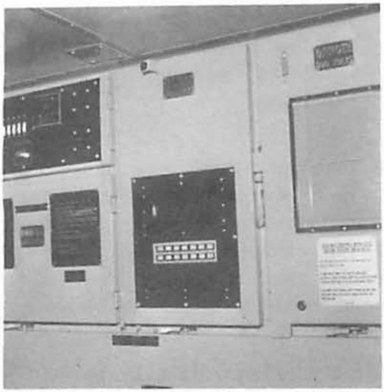


Photo 1

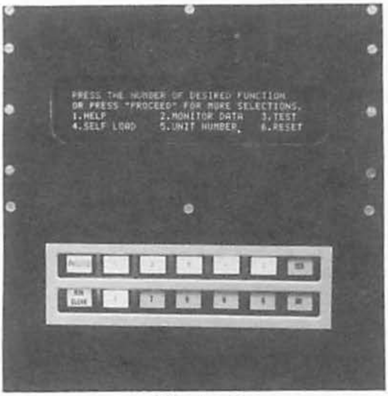


Photo 2

Examples of this type of failure include:

* HOT ENGINE
* GROUND RELAY
* GROUND RELAY — TRACTION MOTOR 3
* GOVERNOR SHUTDOWN
* TURBO LUBE PUMP INOPERATIVE
* TRACTION MOTOR 5 OPEN
* ENGINE SPEED UP—LOW WATER TEMPERATURE
* NO POWER/NO CHARGE
* SIXTH THROTTLE LIMIT
* ENGINE AIR FILTER DIRTY
* NO DYNAMIC BRAKE

Also included are such new messages as "Ground Relay-Traction motor 3 Speed-Up" and "No Dynamic Brakes." These have been designed to provide improved information to the operating crew. These messages will remain on the display screen until the fault or operating condition has been cleared. All "50A" Series locomotives will be equipped with an alarm silence feature, which allows the alarm bell to be turned off by the operator. In addition to the fault being displayed, the fault is recorded in archive memory for retrieval at a later date.

Menu System

All of the Diagnostics/Display functions are selected through a menu-type system with fourteen multifunction control buttons. The menu selections and locomotive information will be displayed on the four-line display screen. To activate the Diagnostics/Display system, the ON button located behind the display screen door must be pressed.

See photo 2.

When performing different functions on the Diagnostics/Display system, only the multifunction push-buttons which are lit will be recognized by the display computer. This feature will assist the user in the selection of items while using the display screen.

Help Function

After the system has been turned on, the first menu appears as shown. We could now make a selection from the six functions. Let's start with the HELP instruction. A selection of the HELP function will provide the instructions for the use of the Diagnostics/Display system as follows:

* THIS CONTROL PANEL IS USED TO:
  - Monitor locomotive operation.
  - Examine the failure history.
  - Test various components and systems.
  - Reset some fault detection systems.
  - Check the time or set the clock.
  - Enter or verify the locomotive unit number stored in archive.
* USE THE "PROCEED" BUTTON TO:
  - Proceed to more selections whenever the "Proceed" button is lit.
* USE THE "RUN/CLEAR" BUTTON TO:
  - Clear the screen.
  - Run the display panel when it is used as a test meter.
* USE THE "YES" AND "NO" BUTTON WHEN A QUESTION ON THE SCREEN REQUIRES AN ANSWER.

The PROCEED function button is used to step through the HELP instruction. When the last help instruction is reached, the RUN/CLEAR button is pressed which allows the user to return to the main menu.

Monitor Data Function

Now let's select the MONITOR DATA function. Button number two is pressed. A second menu now appears, with the MONITOR DATA selections.

For our example of the monitor data function we will select POWER from the second menu. A data packet has been designed for the power monitor and is displayed on the screen. The data pack is a group of parameters which best describes the condition being tested and would appear on the display as follows:

THR POS	....	IREF	....
VOLTS FB	....	RADAR	....
VREF	....	HRSEPWR	....
TMI AVG	....	KW FB	....
ENG RPM	....	KWREF .	....
AMPS FB	....	LOADREG	....

The information for display is continually changing with locomotive operation as a test meter would.

RUN/CLEAR would be pressed to jump out of the power monitor function as suggested by the run/clear light, which would be turned on.

Test Meter

Another feature of the MONITOR DATA function is the TEST METER routine. Let's see how this routine operates: After selecting the TEST METER routine button, the instructions for the selection of signals appears on the screen. The maintenance person could now select up to nine signals which would monitor operation in Power, Load Test or Dynamic Brake.

The PROCEED button would be lit; pressing it allows selection of additional signals from the remaining pages of available signals. After all of the selections requested have been chosen or the RUN/CLEAR button is pressed, the signals will appear on the screen and will provide a continuous display of locomotive operation. If the maintenance person decided to select new signals, the YES button would be pressed to return to the first test meter selection page and start the sequence again.

Test Function

Returning to the main menu, we select the TEST function. The TEST function will allow the maintenance person to automatically test electrical systems such as:

1. cooling fans
2. contactors
3. radar
4. computer
5. ORS
6. load test meter

Let's take a couple of examples from the list of electrical systems. Start with the CONTACTOR TEST button number two is pressed.

Contactor Test

The microcomputer locomotive is no longer equipped with the circuit check test previously applied on "Dash-2" and "50 Series" locomotives. The circuit check test would allow the maintenance person to operate the control circuits when the generator field circuit breaker was opened.

The "50A" Series is now equipped with a feature that allows the maintenance person to automatically test the contactors, reverser transfer switch, motor brake transfer switch and relays, which were previously manually checked in circuit check. In order to use this feature the engine must be shut-down and button two—contactor test—would be selected from the TEST selections.

If a failure was detected during the contactor test, a failure message would appear on the display screen as follows:

* RVR-FORWARD FAILED
TO PICK-UP *

The fault is displayed, and the maintenance person could now trouble-shoot the problem displayed and find the failed component in the circuit.

Load Test Meter Routine

The LOAD TEST METER is one of the features that maintenance personnel will find extremely useful, especially after engine rebuilds, where complete locomotive systems need to be tested.

After selecting that function, the locomotive automatically goes through a load test set up sequence. After the unit is set up, the operator is instructed to advance the throttle. The operator can now select a total of nine signals from approximately 45 available parameters.

The PROCEED button would be lit and if pressed will allow the selection of additional signals from the remaining pages. After all of the selections requested have been chosen or the RUN/CLEAR button is pressed the signals would ap-

pear on the screen and would be continually changing with locomotive operation as a test meter would operate. If the maintenance person decides to select new signals, the YES button would be pressed to return to the first menu to start the sequence again.

Self Load Function

Now, let's look at the SELF-LOAD function. The SELF-LOAD function is similar to the LOAD TEST METER. The difference is that predetermined, fixed test signals are used as follows:

LOAD TEST DATA

THR POS ----	AMPS MG ----
VOLTSMG ----	HRSEPWR ----
LOADREG ----	KWATTS ----
ENG RPM ----	

Unit Number Function

The next function on the main menu is the UNIT NUMBER function. This function allows the maintenance person to view the locomotive number, which has been entered into the computer. This number should correspond to the railroad's locomotive number.

See photo 3.

Fault Reset Function

The next main menu function is the RESET. This function will be used for resetting the following faults:

* Open Circuit Protection
* DG reset
* Locked Wheel

After pressing the RESET FUNCTION button, the following message will appear:

"FAULT RESET COMPLETED"

The fault has now been reset.

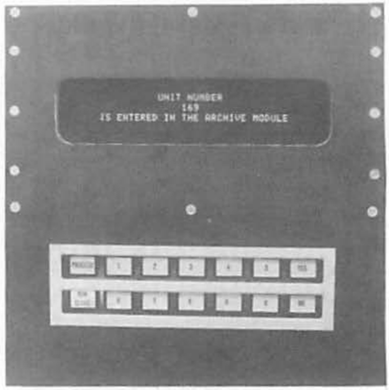


Photo 3

Fault Data Function — Annunciator/Fault History Display Messages

There are fault conditions which will be detected and not immediately displayed on the screen. This type of fault, along with the time and date of the failure, is stored in archive memory.

Examples of this type of fault include:

1. LOW POWER
2. CONTACTOR FAILURES
3. NOT LOADING PROPERLY

Road Failure Fault Detection Fault Message Retrieval

Let's take an example of a road failure where a power contactor has failed. In the past, a locomotive would come into the maintenance point with a report of "not loading." The maintenance person would have to test the locomotive and determine the cause of failure. This could be very time consuming. Today, the EMD "50A" Series locomotive will store the failure message for retrieval by the maintenance person. Let's look at the procedure to display the fault messages.

The first step is to activate the main menu system by pushing the ON button located behind the display panel door. The PROCEED button will light up, indicating the main menu system is ready. Press PROCEED to get to the main menu. Press PROCEED again to advance to the next menu, which contains the FAULT DATA function. The FAULT DATA function would be selected by pressing button one. The FAULT DATA menu will now appear. This menu allows the maintenance person to display fault information as follows:

1) Annunciator Type Faults
2) Entire History To Display
3) List Repeat Failures
4) Entire History To Printer

See photo 4.

1) Annunciator Type Faults: After this function is selected, the display screen will provide the following information to the maintenance person:

ANNUNCIATOR WAS LAST RESET ON 03-29-84 AT 12:15 PM CST. PRESS "PROCEED" FOR 3 MESSAGES WHICH OCCURRED SINCE THIS RESET DATE.

By pressing PROCEED, fault records will be displayed one at a time beginning with the most recent event which has occurred.

In addition to the fault condition, a "Data Pack" containing a "snapshot" of the events at the time of the failure could be viewed by pressing the YES button. After the last annunciator message has been displayed, the "YES" button would be pressed to reset the annunciator. Resetting the annunciator will not delete the fault information from the ENTIRE HISTORY storage.

2) Entire History To Display: Provides a listing of all faults to a maximum of 800 fault messages for display. The maintenance person would PROCEED through the fault history from the most recent date to the earliest failure recorded. In addition to the failure mode, a data pack or trouble-shooting assistance message will appear on the display by pressing the YES button. Examples of the fault and data packets viewed by the maintenance person are as follows:

Example #1:

UNIT 169: GROUND RELAY TM2
OCCURRED 03-30-84 AT 12:50 PM CST

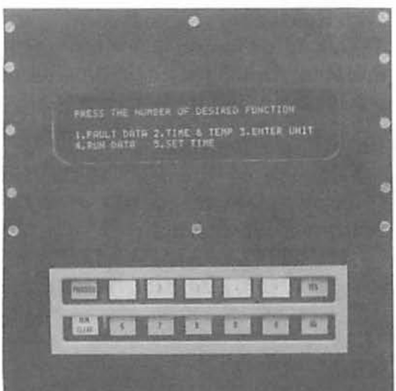


Photo 4

PRESS "PROCEED" TO SEE NEXT EVENT.
PRESS "YES" TO SEE FAULT DATA.

If the PROCEED button was selected, the maintenance person would view the next fault as follows:

Example #2:

UNIT 169: FAILED TO LOAD OCCURRED 04-09-84 AT 6:30 PM CST.
PRESS "PROCEED" TO SEE NEXT EVENT.
PRESS "YES" TO SEE FAULT DATA.

If the YES button was now selected, the maintenance person would view the following message:

P4 CONTACTOR FEEDBACK MISSING

P4 COIL OPEN OR INTERLOCK "EF" FAILED OR IOL MODULE #3 IS DEFECTIVE.

Note: The reported failure of "Not Loading" can now be confirmed by the P4 failure message retrieved from the Archive memory.

3) **List Repeat Failures:** Repeat failures will be accumulated and listed upon selection of this feature.

4) **Entire History To Printer:** Provides a listing of all faults to a maximum of 800 fault messages to an external printer through the communication port. When the number of failures recorded exceeds 800, the earliest failure recorded will be erased to accomodate new data. Information is printed from the most recent date to the earliest failure recorded.

NOTE: The time and date of the failures have been recorded. This feature will assist the maintenance personnel in confirming road failure reports. The information is maintained through battery backup memory in the ARCHIVE MODULE and will not be lost during locomotive shut-down.

Run Data Function

Running Totals

Returning to the second page of the main menu, let's go through the procedure to operate the RUN DATA function. The selection of RUN DATA provides a "Running Data Monitor" menu as follows:

RUNNING DATA MONITOR

1. Running Totals
2. Duty Cycle
3. Trip Monitor

If we select the first function, RUNNING TOTALS, we see the following:

Accumulated Running Data
From 12-01-83 to Present.
Multiply Numbers by 1000.

KW Hours -----	Miles -----
HP Hours -----	Hours -----

This information has been accumulated from the day the locomotive was put into service.

Duty Cycle Routine

Selection of the DUTY CYCLE from the main menu will give the following information:

MULTIPLY ALL VALUES
BY 100 EXCEPT THR.

TH	8	7
MILES	--------	--------
HRS	--------	--------
HPHRS	--------	--------
KWHRS	--------	--------

This information is the accumulated running totals from the in service date to present. This allows the maintenance person to view the duty cycle history of a particular locomotive. Throttle positions 7 and 8 are shown, although, by pressing PROCEED all of the throttle positions and trip totals will be displayed. The accumulated totals cannot be reset. THE DUTY CYCLE ROUTINE will accumulate data for the locomotive life.

Start/Stop Trip Monitor

Now let's look at the START/STOP TRIP MONITOR. If the locomotive is going to make a trip and the maintenance person is interested in the performance data for that trip, the TRIP MONITOR can be started. The TRIP MONITOR would record data which can be used to compare locomotive performance on units operating within the same consist. This information can also be used to isolate a report of a locomotive "Not Loading Properly" or to determine the duty cycle on a particular trip.

After the trip has been completed, return to the TRIP MONITOR menu to stop the TRIP MONITOR and view the accumulated information by pressing the YES button. After the last section of information has been viewed, the screen will display, "End of Trip Data."

Future Expansion

The capability of the computer permits its use to extend far beyond the areas presented. Some of the areas for future expansion include:

1. Improving automatic failure analysis techniques to identify the cause of a fault at the lowest component level possible.
2. Provide expanded interactive troubleshooting, which will extend the computer fault analysis beyond the capabilities of the available feedback information.
3. Add new transducers to the mechanical systems to expand the real-time diagnostics capabilities in these areas.
4. Provide programmable features that would control acceleration and speed limits in order to improve fuel economy.
5. Provide customer programmability to accomodate custom diagnostics or locomotive/train operation analysis.

Conclusion

The Diagnostic-Display computer system offers fault annunciations through a four-line display panel. Onboard diagnostics, interactive troubleshooting, and locomotive event and fault history storage are features that have not been available to the railroad industry prior to the development of the microprocessor control system.

II.
GENERAL ELECTRIC DASH 8 DIAGNOSTIC DISPLAY

In General Electric's new DASH-8 microprocessor locomotive, its computer system contains all of the information that was supplied by indicating lights and test points on previous models.

This is done by means of a Diagnostic Indicating Display panel, (DID). It is located on the engine control panel in the operating cab. The panel is a rugged, solid state device. The keypads are touch pads, and there are no mechanical moving parts.

See photo 5.

There are several different uses for this panel.

1. STATUS messages for road crews.
2. FAULT messages for road or shop personnel. A 'fault' is any abnormal condition detected by the computer system.
3. SELF TEST of the locomotive systems.
4. INSTRUCTION messages for shop personnel to aid in diagnosing locomotive problems.
5. MONITORING specific functions of the locomotive.

Status Messages

On the road, the engine crews will see messages appear on this panel in place of the indicating lights that were mounted in this same location on previous locomotive designs. The only difference is that the message will be more complete. The indicating lights and controls and switches on the control stand remain the same as before.

The only messages that will appear are those that require some action from the operator, or that will help him in reporting his status for a work report or a radio report.

Some typical STATUS messages are . . .

READY

See photo 6.

ISOLATED

LOAD LIMITED: HOT ENGINE

LOAD LIMITED: COLD ENGINE

LOAD LIMITED: LOW WATER PRESSURE

LOAD LIMITED: ELECTRICAL CONTROL PROBLEM

The trainline alarm bell will function as before . . .

A continuous bell indicates that an engine has been shutdown by the control system. This might occur on ENGINE OVERSPEED, LOW FUEL PRESSURE, etc.

An alarm that stops after 30 seconds means that a fault has occurred, that the engine is no longer on the line, but it is running at idle speed and battery charging continues.

If more than one message occurs at the same time, the one with the highest priority will appear. The engine crew can see the other messages by using the DID panel key pads. If a message is not ACKNOWLEDGED it will go off after 30 seconds. Touching any keypad of the DID panel will then bring back the display.

Fault Messages

Here are some examples of messages and what action is required of the engine crew:

"LOAD LIMITED: DIRTY ENGINE AIR FILTERS"

Beneath the message line a second line appears that labels the 5

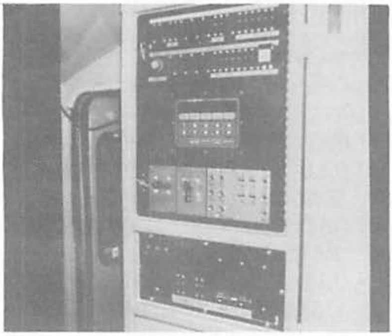


Photo 5

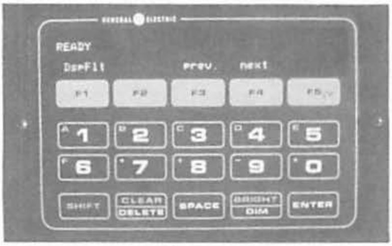


Photo 6

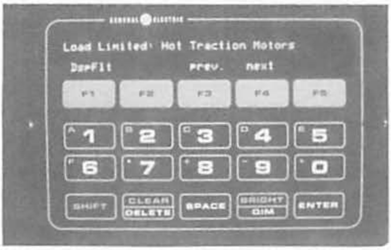


Photo 7

Photo 8

keypads (F1 - F5) below the second line. These keypads are used to control the DID panel.

The complete message would be . . .

Beneath the message line a sec-

See photo 7.

Pressing the "RESET" keypad will clear the message.

A FAULT message might look like this . . .

"WON'T LOAD: HOT DIODES"

"RESET"

or . . .

"SHUTDOWN: ENGINE OVERSPEED"

"RESET"

If a fault is detected, requiring no action of the engine crew, the message might be . . .

"FAULT MESSAGE STORED"

Shop Maintenance Uses

If a series of faults have occurred on the road, each of them is stored within the memory, even though it is not displayed.

The shop maintenance people can see these messages by entering a password on the keypads on the DID panel. When they enter the password, then the display will show all of the stored faults one by one, on command.

When the fault is repaired, this can be put into the computer memory by the shop man when he presses the keypad labeled

"RESET"

The computer will note the time of the original fault and the time when repair was reported.

Shop forces will be able to monitor engine water temperature and various pressures.

See photo 8.

Self Test

If desired, the shop forces can put the unit through self test. To do this, they set up the controls for the function that is to be tested, motoring, braking, self-load, etc., and then select AUTO TEST or MANUAL TEST. AUTO TEST will run by itself, MANUAL TEST will go one step at a time, displaying what the next test is before it is done. The testing procedure will make all electrical measurements by itself, and the operator will be able to observe mechanical events, such as main reservoir drain valve operation, load ammeter calibration, etc.

Diagnostics

If an electrical fault is detected, the DID panel can provide a sequence of tests and checks to be made to locate the point of failure. The operator can use a test meter to check at points not checked by the computer.

Monitoring

By entering the proper password, authorized personnel will be able to monitor activities within the various systems. This includes such things as lube oil temperature, cooling water temperature, volts, amps, motor temperature, horsepower, ambient temperature, diesel engine RPM, etc. These functions are to aid the shop people during locomotive or engine testing and can also be observed on the road for special testing or investigations.

This one panel simplifies the observing and testing of the locomotive equipment. All of the test points that were provided on the various electronic cards are replaced in the DID display.

III.
"PROBE" LOCOMOTIVE DIAGNOSTIC EQUIPMENT

Previous sections of the presentation covered the approach taken by two major locomotive manufacturers for the next generation of locomotives. We are now going to cover an auxiliary system available as an add-on diagnostic unit for existing locomotives.

The PROBE system from Harris Controls was developed for Canadian Pacific and demonstrates use of extensive techniques for measurement of a multitude of characteristics on the locomotive. It has the capability to monitor in-depth performance of the locomotive and engine components and also produce an overall performance report of the recent history.

See photo 9.

Basic components of the system are an "on board" monitoring and memory system, a portable transfer unit and a base report compiler for further analysis.

Monitoring System

The monitoring system is the locomotive portion of the PROBE system. It consists of:

- An electronics module
- A display panel
- Transducers — temperature, pressure, etc.
- Signal isolators

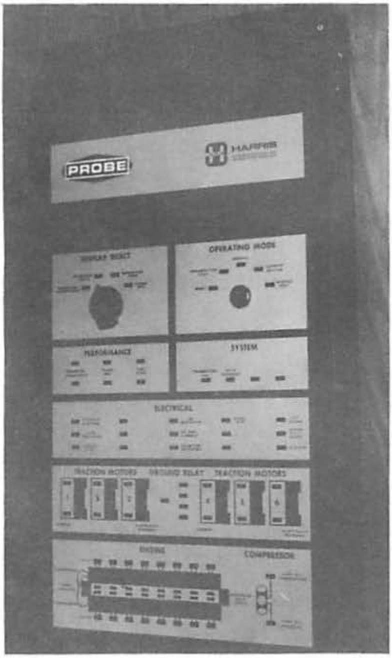


Photo 9

It monitors various parameters via the transducers and signal isolators. The performance is compared with the limits for the operating mode. If the limits are exceeded, then an indication occurs on the display panel and data is stored as a Fault Record. Data is recorded every 1/10 mile and the memory has sufficient capacity for 1,500 miles. When the memory is full, the oldest data is replaced by the most recent incoming data.

The operating parameters are compared with their previous values. If the operating conditions change significantly, an Operating Record is stored in the memory.

Periodically, averaged performance data is retained to provide a Trend Record.

Data in the memory (fault records, operating records, trend records and cumulative data) is passed to the Data Transfer Unit whenever it is connected to the locomotives. Data is in turn transferred to the Analysis System which analyzes and prints a summary of the information.

The following is a sample of the locomotive functions that can be monitored depending upon choice of the user:

- Wheel Slip
- Ground Relays
- PC Trip
- Dynamic Brake
- Hot Engine Governor Shut-Down (LOS)
- Hot Suspension Bearings (12)
- Throttle Response Load Regulator
- Load Regulator Voltage
- Turbocharger Vibration
- Air Compressor Lube Oil, Temperature and Pressure
- Cylinder Compression
- Cylinder Firing Factors
- Traction Motor Currents
- Horsepower
- Fuel Flow Rate
- Engine RPM
- Engine Shut-down

See photo 10.

Additional options are available for monitoring air brake pressures at the reservoirs and in the brake pipe together with air flow and independent brake operation.

Obviously, as more equipment is added to a locomotive, the poten-

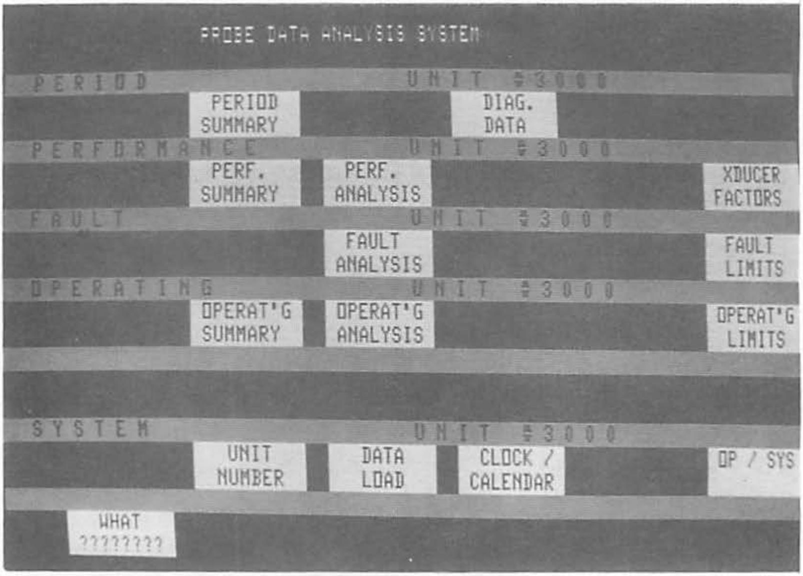


Photo 10

tial for failure will be increased. Accordingly, the monitor unit is fitted with a "Transducer Check" function that will indicate possible errors. It would be prudent to check the monitoring transducers prior to making a component change out just based upon reports.

Operating functions monitored by the unit and the basic data included for a report are:

- Unit Number
- Time and Date of Data Transfer
- Time and Date of Previous Data Transfer
- Cumulative Distance
- Cumulative Fuel Consumption
- Idle
- Throttle #1 — Throttle #8
- Dynamic Brake
- Engine Shut-down
- Low Idle

Data that can be directly displayed on the locomotives are as follows:

- Stored Faults (Normal)
- Fault Resets
- Current Status
- Transducer Test
- System Test
- Internal Display

Direct Read-Out Is Available For:

- Horsepower
- Generator Volts
- Generator Amps
- Engine RPM
- Internal Display

Distance is calibrated by use of track located distance calibrators, which are passive and maintenance free. It is recommended that they be placed in the track at 50 or 100 miles or locations as may be convenient.

Data Transfer Unit

See photo 11.

The Data Transfer Unit (DTU) transfers data from the monitoring system on the locomotive to the Data Analysis System. It also updates the onboard system clock, data limits and calculation parameters at the same time. The transfer unit can store data from several locomotives at the same time.

The DTU is a microprocessor-controlled unit that communicates to the user through front panel indicators the following conditions:

TRANSFERRING, when a data transfer is in progress. This indicator lights at the start of each data transfer and remains on throughout the entire transfer cycle.

TRANSFER COMPLETED, after a data transfer is completed.

TRANSFER RE-ENTRY, when input requirement has not been met and the systems are attempting another transfer.

TRANSFER FAILED, if data cannot be transferred because of a system malfunction.

HIGH TEMPERATURE, LOW TEMPERATURE, indicates that the internal temperature of the DTU is beyond the limits for reliable operation. The unit will not function until the internal temperature is within the limits of -10 to +50°C.

DATA BLOCK, a series of four indicators show the number of memory blocks available in the DTU. They indicate to the operator the number of locomotives whose data can be serviced by the transfer unit.

Operation

When the transfer unit is plugged into the locomotive or analysis system, it signals it is ready (temperature within limits) and power is applied to the transfer unit.

Data is then automatically transferred between the units. The transfer unit contains a real-time clock to update the monitoring system on each data transfer. The transfer unit clock is in turn updated by the analysis system. Also included is a "message" area through which the analysis terminal may change data limits and/or other parameters. The "messages" may be directed to a class of locomotives or to a single locomotive.

Remote Transfer

The techniques and equipment are available for transmission of data from the transfer unit by telephone modem. This could be used for transfer from a "round house" to a regional or corporate headquarters. The technology is also available for use with a low power radio transmitter to transfer information enroute.

Periodic Maintenance

The Data Transfer unit requires minimal maintenance, the only recommendation being that the batteries should be replaced annually (three alkaline C-cells). Care should be taken to avoid exposing the unit to excessive temperatures or shocks.

Data Analysis System

See photo 12.

The Data Analysis system comprises a computer terminal with CRT Display Tube, printer for hard copy reports and a typewriter-type keyboard for communicating with the system.

Photo 11

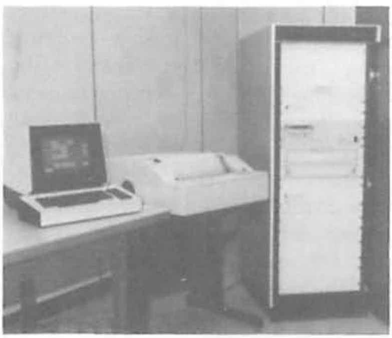


Photo 12

Control, logic and memory functions are contained in a separate cubicle together with the relevant power supplies and support equipment.

The purpose of the Data Analysis System is to accept, store and analyze data from the on-board Monitoring System. Incoming Data from the Transfer Unit is stored on a disk memory and analyzed by system programs also stored on a disk.

System control is accomplished through operator selection of the function required from a list displayed on the CRT screen. Selection is obtained by touching the desired item on the face of the screen. The system then displays data about locomotive performance and train operations as requested.

A. Summary of the main functions available is as follows:

1. FAULT ANALYSIS
   Provides tabular printouts of fault conditions on the locomotive. This includes all the parameters on the monitoring system display panel:
   - All data from the latest transfer is available
   - Selective faults or all faults can be displayed and/or printed
   - Touch screen, anywhere, and it begins to print all faults
2. ENGINE PERFORMANCE SUMMARY
   Produces a printout containing

a summary of the engine performance:

Total horsepower hours
Total fuel consumption
Overall engine efficiency factor
Time at each operating mode
Distance traveled

Data may be from latest period — latest 10 periods or total cumulative data.

3. LOCOMOTIVE FAULT SUMMARY
Provides a printout of:

The number of faults detected during the period, and
The time of out-of-limit conditions

Data is derived from:
The latest period or latest 10 periods
It is recommended that a period summary be printed whenever data is loaded from a monitoring system

4. SYSTEM DIAGNOSTIC
Data accumulated in the on-board monitoring system may be used to diagnose failures or marginal conditions and is transferred to the analysis system via the DTU. This function prints the diagnostic data which includes:

Internal system voltages
Power fail counts
System configuration and failures
Process fail counts

5. PERFORMANCE ANALYSIS
Provides a graphical analysis of engine performance factors over a period of time. These factors include:

Throttle #8 horsepower
Throttle #8 fuel flow
Throttle #8 turbocharger vibration.
Power assembly compression and firing factors

Data may be taken from the latest 10-20 days or from selected periods.

6. OPERATING SUMMARY
Prints out a summary of the train operations data available in the analysis system. This includes the track locators names, time and dates.

7. OPERATION ANALYSIS
Prints a report of train operations which includes:

Operating modes
Air Brake Operations
Speed Profile (vs. distance)
Alarm Conditions

Any or all of the trip segments available in the analysis system may be printed.

8. UNIT NUMBER
Used to select engine to be analyzed.

9. SYSTEM LIMIT FUNCTIONS
All other functions are limit change and data base access functions that require a password to enter.

IV.

CATS — (COMPUTER AIDED TROUBLE SHOOTING)

General Electric Company is developing a Computer Aided Trouble Shooting system, with the acronym CATS, to assist railroad maintenance people.

See photo 13.

The computer world using what is known as "Artificial Intelligence" has developed an "EXPERT" system. That system is capable of interpreting answers entered into the computer and comparing those answers to a large group of "rules." Those rules must have been previously entered by someone with a good understanding of locomotives and a lot of trouble-shooting experience.

CATS includes a variety of "HELP" information that the user can call for. These data are presented as a menu. Types of help include color slides, line drawings, selected portions of locomotive schematics, short color movies of procedures such as setting fuel pump racks, pump timing, etc.

The purpose of CATS is to guide shop forces in their analysis of symptoms to find the actual problem.

CATS also assists in training programs. When a new worker uses CATS, he will be guided through specific symptoms and will

Photo 13

see the various questions that he will be required to ask himself on the job. He will see what type of training or maintenance material is available on his railroad.

CATS consists of a large set of rules that cover a selection of problems that might exist on GE locomotives with CHEC excitation and CMR wheel slip equipment.

The system includes a shop-hardened keypad, computer and monitor, a video disk and monitor, and a printer.

Each time a man uses this equipment to guide him, he will learn more about what he should have done before he came to the computer. Each time he will progress further, and soon he will find the problem without the need of CATS.

Thus CATS will be able to . . .

* PROMPT an experienced man,

or

* GUIDE one with less experience,

or

* TEACH a novice a way to search for the problem.

As an example of CATS, the enclosed printout shows the procedure that was followed when all that was known was NOT LOADING PROPERLY.

The problem was caused by these faults:

1. Engine fuel pump racks were not properly set
2. Fuel pressure gage was defective.
3. The fuel pressure control valve was set too low.

Welcome to CATS — 12:56:52 13 JAN 84
Resetting: Facts, Rules
The reported symptom is — NOT LOADING PROPERLY

QUESTION: Let's make sure that the operating controls in the cab are set up properly. Maybe engine crews have it wrong.
Power Limit Switch is on the Master Controller.
Is it in the NORMAL position? Yes

QUESTION: Not all locomotives are equipped with MOTOR CUTOUT
Are all traction motors cut in? Yes

QUESTION: Not all locomotives are equipped with HUMP CONTROL
If HUMP CONTROL is provided, is it turned OFF at Master Controller? Yes

QUESTION: Not all locomotives have PACE SETTER OPTION
If PACE-SETTER is installed on this unit, is it CUT OUT? Yes

These are possible fault areas:

1. The engine may be unable to make full power
2. The excitation demand may be low
3. The contactor sequence may be incorrect
4. An auxiliary system may be overriding excitation demand
5. An auxiliary engine support system may be faulty
6. None of the above. End of Not Loading Properly session.
   SELECT: Select by number the area you want to work with . . . 1

These are possible states of the engine:

1. The engine is shut down
2. The engine is idling
3. The engine is at full-speed/no-load
4. The engine is at full-speed and load
5. None of the above. Terminate current session.
   SELECT: Select by number the state that you want to see . . . 2.
   QUESTION: Is the governor steady? not hunting No
   QUESTION: Is the governor oil clean? Yes
   QUESTION: Is governor oil level visible in sight glass? Yes
   Adjust Governor Compensating Needle Valve. Normal setting is OPEN ½ turn.
   *** DO NOT BREAK GOVERNOR SEAL ***
   Adjustment is on lower part of governor in back. Please confirm when done: Yes
   QUESTION: Now, is the governor steady? Yes

See photo 14.

QUESTION: NOTE. You can check idle speed WITHOUT a tachometer. A 4-stroke cycle engine fires each cylinder every other revolution. So at 450 RPM you hear 225 firing pulses in one minute, if you pull one rack out just a little.

That's 56 counts in 15 seconds. (450 RPM idle)
—or 50 in 15 seconds for 400 RPM idle.
—or 48 in 15 seconds for 385 RPM (Low idle)
—or 36 in 15 seconds for 275 RPM (Low-low idle)

Most engines are set to idle at 450 RPM, 669 at tachometer drive, but there are exceptions.

Check your schematic diagram speed.

Is speed OK? Yes

QUESTION: Is the power-piston gap normal? 1" ± 1/32 No

QUESTION: Is power-piston gap less than normal? Yes

QUESTION: Are ALL the fuel racks between 5 and 6mm? Yes

Fuel pump racks are set too low, or overspeed link not in RUN position or wrong fuel lever applied. If racks are much too short, or overspeed link is far from normal, the load pot may be MIN FLD, if tailrod gap less than .9" Governor is OK

Shut down the engine

Please confirm when done: Yes

Install gage block,

Apply tailrod jack, and set fuel racks to proper value.

See photo 15.

If you find racks are properly set, then it means that someone has applied the wrong FUEL LEVER to the layshaft linkage. Check service manual for correct lever and install proper length lever.

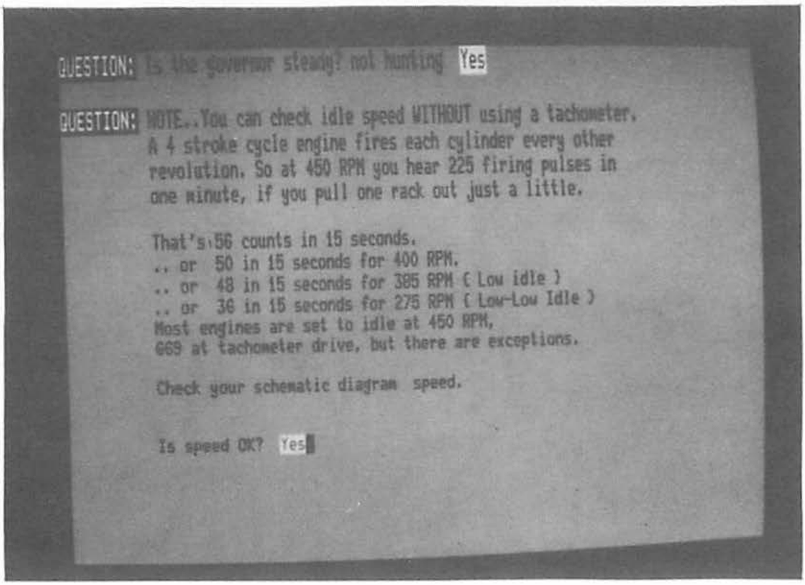


Photo 14

If you are not sure of proper rack setting, then check shop manual section DE-14

* * * CAUTION * * *
TAKE PRECAUTIONS TO PREVENT ANYONE FROM CRANKING ENGINE!

* * BE SURE TAILROD JACK IS OUT BEFORE CRANKING * *

Please confirm when done: Yes

Crank and start the engine

Please confirm when done: Yes

QUESTION: Now, is the power piston gap normal? Yes

The Governor Speed Control System is OK.

QUESTION: Is the stack clear? Yes

Starting POP-TEST procedure to check fuel combustion:

At each cylinder pull the rack out 2-3mm and listen to sound of cylinder firing. Please confirm when done: Yes

QUESTION: Do you hear a sharp crack when firing, without any valve blow sound at each cylinder? Yes

The Combustion System is normal.

QUESTION: Is load control pot at MAX FLD? 5:30 position Yes

QUESTION: Is fuel pressure normal? between 38 and 42 psi No

Since the fuel pressure is not normal, indicate its current value.

These are the possible values for abnormal fuel pressure:

1. Fuel pressure is below normal (less than 38 psi)

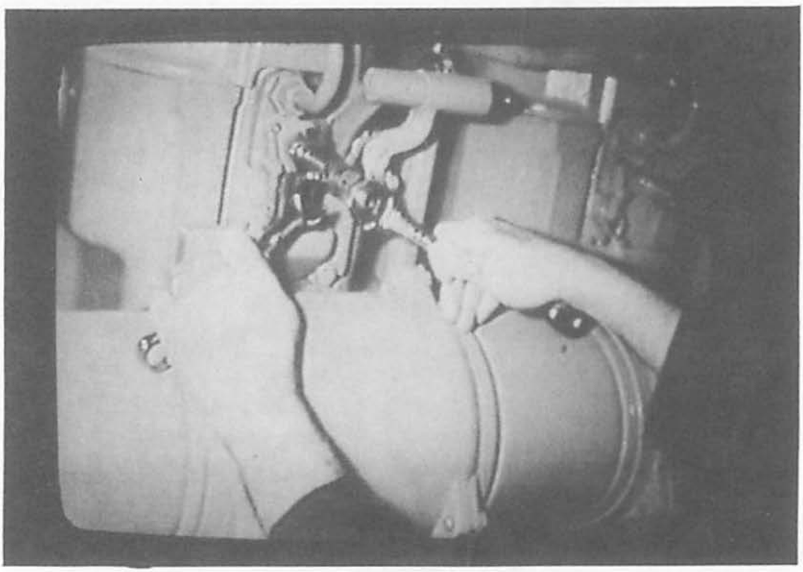
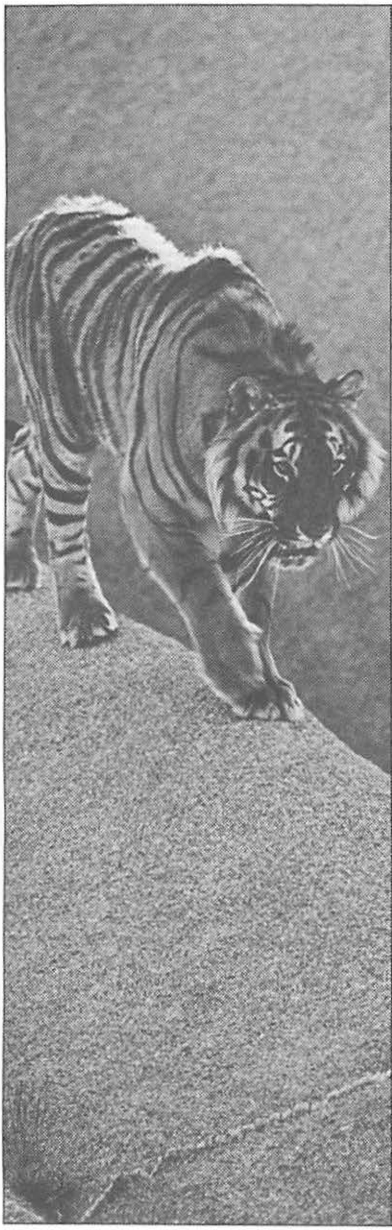


Photo 15



2. Fuel pressure is above normal (more than 42 psi) the fuel pressure is normal (38-42 psi)

SELECT: Select by number the correct fuel pressure. 1
Since the readings indicate an abnormal fuel pressure, we want to know how the readings were taken. Please, indicate which fuel pressure gage was used:

1. The locomotive fuel-pressure gage
2. The test fuel-pressure gage

See photo 16.

SELECT: Select by number which fuel-pressure gage was used: 1
Attach a known good pressure gage.
Please confirm when done: Yes

QUESTION: Is test-gage reading the same as loco-gage reading? No

The loco-pressure-gage is bad.

Replace the loco-pressure gage.
Please confirm when done: Yes

QUESTION: Now, is the fuel pressure normal? No

There is a fuel system fault.

QUESTION: Does the fuel-tank-gage show that there is enough fuel in tank to get good suction? Yes

QUESTION: Is fuel-transfer-pump-motor running normally? Yes

QUESTION: Does this unit have a fuel filter drain valve? Yes

QUESTION: Is the fuel filter drain valve CLOSED? Yes

QUESTION: Is the fuel-filter clean? Either check pressure drop, or verify that it was changed. If you don't know for sure, answer with "NO" Yes

QUESTION: Is this unit equipped with a fuel strainer? Yes

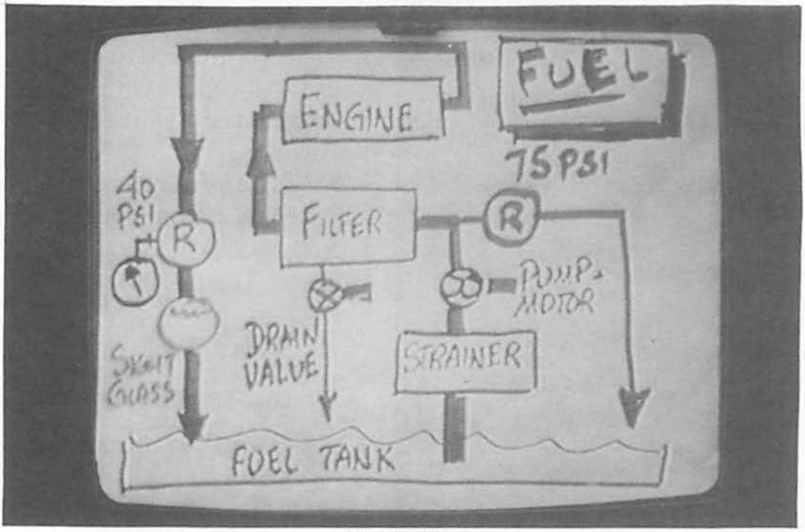


Photo 16

QUESTION: Is the fuel-strainer basket clean?
Be careful of the O ring in the lid. Yes

QUESTION: Is the fuel-strainer gasket in good shape? Yes
Try to change fuel pressure with regulating valve. Please confirm when done. Yes

QUESTION: Are you able to set fuel pressure to 40 psi? Pressure won't change if valve is defective. Yes
The Fuel System is normal.
The regulating-valve was set wrong.

QUESTION: Now, is the fuel pressure back to normal? Yes
The fuel problem appears to be solved.
Rechecking at full load must be done to be sure.

QUESTION: Is the lube pressure above 30 psi? Yes
The Lube-Oil System is normal.
The engine is OK at idle.
Put engine at full-speed/no-load.
Please confirm when done. Yes

QUESTION: Is the governor steady? not hunting. Yes

QUESTION: Is load control pot at MAX FLD? Yes

QUESTION: Is fuel pressure normal? between 38 and 42 psi. Yes

QUESTION: Is lube pressure above 70 psi at the governor? Yes
The Lube-Oil System is normal.

QUESTION: Most engines are 1046-1054 RPM, for full speed. 1555-1567 at tach drive, but there are exceptions.
Is speed correct? Check schematic diagram. Yes

QUESTION: Does the turbo air gage show zero to 2 psi? This is normal, since there is almost no engine load. Yes

QUESTION: Is the stack clear? and does it sound normal? Yes
The engine is OK at full-speed no load.
Put engine at full-speed and load.
Please confirm when done. Yes

QUESTION: Is the governor steady? not hunting. Yes

QUESTION: Is power-piston gap normal? 0.344" Or 11/32" Yes

QUESTION: Are fuel racks normal? See DE-14 for setting. Yes

QUESTION: Is load control pot between 4:00 and MAX FLD? Yes

QUESTION: Is fuel pressure normal? between 35 and 40 psi. Yes

QUESTION: Is the lube pressure above 70 psi? Yes
The Lube-Oil System is normal.

QUESTION: Most engines are 1046-1054 RPM, for full speed, 1555-1567 at tach drive, but there are exceptions.
Is speed correct? Check schematic diagram. Yes

QUESTION: Is the turbo air pressure normal for this engine? Consult PERFORMANCE GUIDE CHART for values. Yes

QUESTION: Is the stack clear? and does it sound normal? Yes
The engine is OK at full-speed and load.
No problems are found with the engine.
There are more areas to check, electrically . . .

V. FUEL CONSERVATION THROUGH ELECTRICAL MODIFICATIONS — GE

This report will concentrate on the electrical modifications designed to reduce the amount of fuel GE locomotives consume.

The percentages used to demonstrate the amount of fuel saved is for locomotives operated on a medium road duty cycle. The percentages contained in this report cannot be combined to indicate the total fuel savings possible if all the electrical modifications are installed. This is due to the fact that different systems overlap, thus sharing in their fuel savings capabilities. The percentage of fuel savings possible is for the use of that system only.

See photo 17.

1. Low Idle

This feature allows the engine to rotate at lower than normal RPM while in idle, under certain conditions. Since the engine is rotating slower, less fuel is consumed. A 1.2% fuel savings can be realized through the low idle feature.

The locomotive must have its reverser handle centered or the engine isolated, and the engine water temperature must be above 150 degrees F before the unit will go into the LOW IDLE mode of operation.

2. Engine Speed Schedule/Motoring

The engine speed schedule was changed to the SKIP 3 DOUBLE 6. This speed schedule improves the throttle response of the locomotive and continues to reduce emissions. A fuel savings of 1.5% is realized with this speed schedule. As the throttle is advanced from notch 1 to notch 8, the engine speeds will respond as follows: 1-2-4-5-6-6-7-8.

See photo 18.

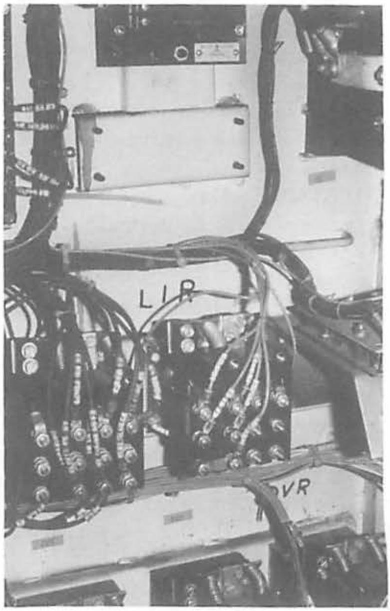


Photo 17

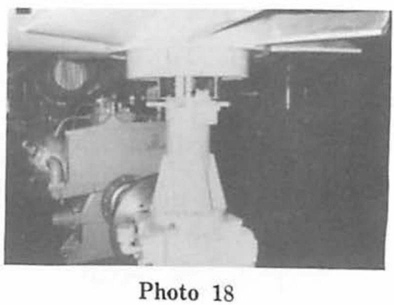


Photo 18

3. Eddy Current Clutch

This system allows the cooling fan to run only when cooling is required. The fan operates at two different speeds. The fan is off if the cooling water is below 180 degrees F, at low speed if the cooling water is above 180 degrees F, and at high speed if the cooling water is above 190 degrees F. This system provides a fuel savings of 2.5%.

4. Part Throttle Load Schedule

This feature increases the excitation in the intermediate throttle notches without changing the amount of auxiliary load. This allows the locomotive to be more efficient in its use of fuel in the intermediate notches and use about 0.7% less fuel.

See photo 19.

5. Modulated Braking

This feature allows the speed of the engine to vary while in dynamic braking and thus save fuel. This new control system will follow the Braking Control Handle and run the engine at the proper speed to insure Grid and Traction Motor cooling.

Typically, the engine speed will be at idle during the first third of the motion of the Braking Control Handle, notch 4 speed for the middle third, and notch 8 during the last third. A fuel savings of 0.33% can be realized through the use of this system.

6. The Braking Grid Hatch

The Braking Grid Hatch contains a Grid Blower Motor that gets its power from the current passing through the Grids. The fuel saved is from a reduction in auxiliary load and increased radiator fan efficiency. A fuel savings of 0.7% can be realized through this system.

7. The New DASH-8 Locomotive

The new DASH-8 locomotive contains the following features that cannot be retrofitted to DASH-7 locomotives. The DASH-8 locomotives can realize a fuel saving of from 2-4% over the previous model.

1) The speed of the Traction Motor Blowers are controlled by the Traction Motor temperature.
2) The speed of the cooling fans are controlled by the computer based on the cooling water temperature.
3) The engine speed is controlled by the computer to obtain the desired horsepower. If full horsepower can be developed at less than full engine speed, then it will, unless higher speed is needed for cooling purposes.

The electrical modifications listed above have improved fuel efficiency, thus reducing the expense of operating GE locomotives.

VI.

FUEL SAVINGS THROUGH ELECTRICAL MODIFICATIONS — EMD

The railroad industry now is well into the second decade of higher fuel prices. During this period nearly a 1000% increase in

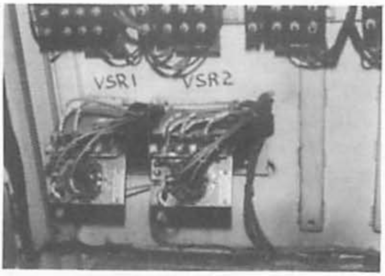


Photo 19

fuel prices has occurred. Fuel and labor costs today share almost equal percentages of the operating dollar.

Up to this point, the Electrical Committee has presented many of the new innovations that can be directly beneficial to fuel savings and maintenance. What has not been discussed is the retrofit packages of electrical control systems that can be placed on the existing fleet. Everyone is dealing with the "existing fleet" so, naturally, they are the most important. These are the immediate things that can be done—the real dollar savings that can be achieved now. Cut that fuel bill; reduce that operating cost, or at a minimum keep those costs below inflation rates.

See photo 20.

Engine Low Idle

EMD offers a Modernization Recommendation in MI #9619 for about $610 today, depending on the unit. The parts list is shown below.

Application of the 255 RPM Part Time Low Idle feature involves readjustment of the engine governor speed settings and the installation of a low idle panel in the electrical control cabinet.

Part No.	Qty./Unit	Description
9316185	1	Low Idle Panel
8498214	1	Nameplate
8149306	1	Speed Scale (Governor)
8250906	A.R.	Faston Lug
8198189	A.R.	Terminal Lug — ¼"
8200891	A.R.	Splice (Faston Connector)
8472022	A.R.	No. 14 Wire (500 Feet)
8194927	A.R.	Wire Tags — Letters
8194928	A.R.	Wire Tags — Numbers
9419644	4	No. 10-24 Bolt — Self-Tapping
*9092231	1	10 Ohm Resistor
**8357417	1	Relay
***8455355	1	Switch
***8421017	1	Rectifier
****8363168	1	Relay

AR - Denotes As Required
* Used only on units with AC auxiliary generators
** 6 Pole (5-N.O. 1-NC) replacement relay for the FPC or FPCR when necessary
*** Used only on non-MU SW1500 and MP15 units
**** Used only on MP15AC units (when necessary)

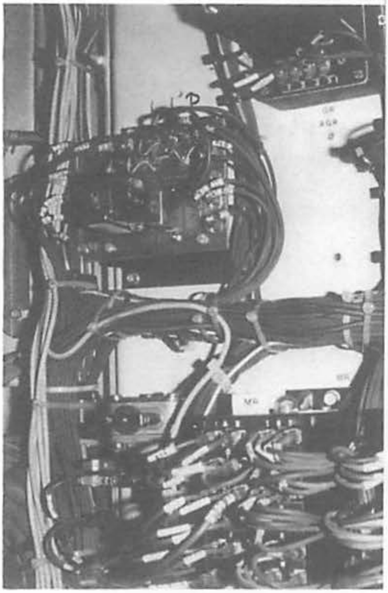


Photo 20

What does the package do? It provides reduced fuel consumption, reduces emissions and lowers engine noise. The last two items are very important but often forgotten. Those are free in a sense. The fuel, of course, is the heart of the system. Dropping the idle from 315 RPM to 255 RPM will save 0.7% based on EMD's medium duty cycle (46% of the time in idle) as shown in Reference A. That amounts to about 2800 gallons per year. The ROI is about two months on GP-40-2's and SD-40-2's. From Graph 1, one can determine the potential savings. If over the last four years you were paying $0.80 per gallon, you would have saved approximately $9000 per unit, less the material and installation cost.

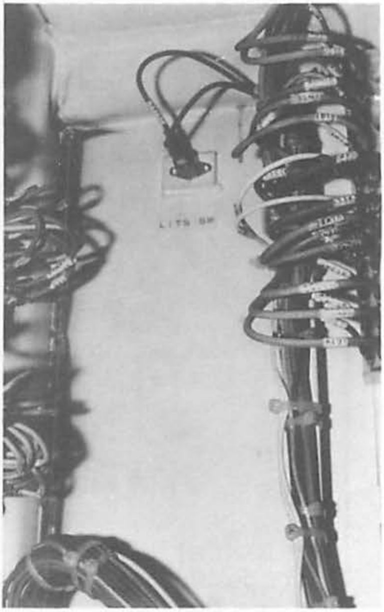


Photo 21

See photo 21.

An additional low idle thermostat that costs about $10 is recommended with the Part Time Low Idle package. What this does is automatically put the engine at 315 RPM when the ambient temperature descends to 0°F (-18C). The 225 RPM will occur as the temperature ascends to 10°F (-12C). This keeps the water temperature above 160°F (71C). Consideration should also be given to having a gear-driven oil pump on the air compressor. Since this is not a kit, the parts requirements are listed below.

Part No.	Quan.	Description
9518967	1	Thermostat
9519039	1	Pad

Medium Road Duty Cycle of Operation

GP/SD40 or GP/SD40-2 w/16-645E3 Engine

Throttle Position	Engine RPM	Duty Cycle (Total Operating Time)	Throttle Position Fuel Rate Gal./Hr.	Duty Cycle Fuel Rate Gal./Hr.
8	900	17%	167.7	28.5
7	815	4%	145.8	5.8
6	730	4%	108.5	4.3
5	645	4%	79.0	3.1
4	560	4%	57.2	2.2
3	480	4%	41.4	1.6
2	395	4%	24.9	.9
1	315	4%	7.4	.2
Idle	315	46%	5.5	2.5
Dynamic Brake		9%	21.0	1.8
		100%		50.9 Total Gal./Hr.

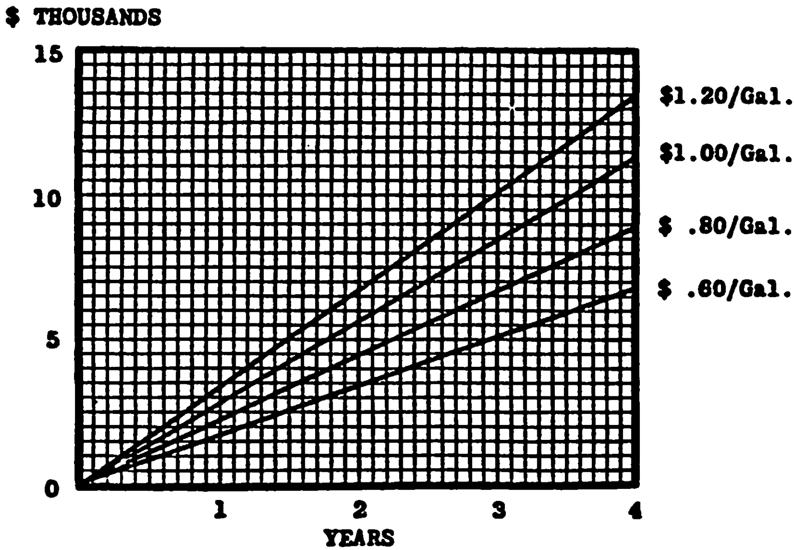
REFERENCE A

PROJECTED ANNUAL FUEL SAVINGS

GP40-2 OR SD40-2

The "Low Idle" feature produces a

0.7% or 2800 Gallon Annual Fuel Savings.



GRAPH I

An additional 1.1% can be achieved by applying a full time low idle of 200 RPM from the part time low idle of 255 RPM. This projection is again based on a medium duty cycle as outlined in Reference A. Changing to 200 RPM full time low idle requires a unit exchange governor and the installation of the 18KW Super Auxiliary Generator. This will change return on investment. With the 200 RPM low idle an air main reservoir pressure switch is recommended. When main reservoir pressure drops to 115 PSI, the engine speed is raised to Throttle 2 RPM and maintained until main reservoir pressure reaches the normal shut off point, typically 135 to 145 PSI. Investment costs are higher in this case and should be evaluated by the user.

The simple physics of the fuel savings for the low idle feature pertains. Depending on duty cycle, treatment of the labor cost, productivity and associated locomotive daily availability value, the savings will vary. The M. I. 9619 will provide the details necessary for installation.

See photo 22.

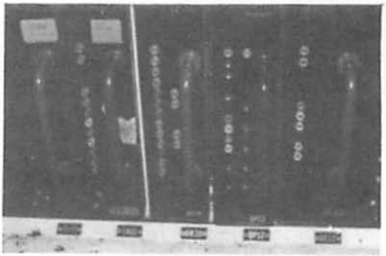


Photo 22

Two Speed Dynamic Brake

The Two Speed Dynamic brake modernization is described in M. I. 9661 (pre dash 2) and M. I. 9648 (all dash 2) will afford users with up to 1.1% annual fuel savings. The dash 2 retrofit currently sells for $1,200 and the pre dash 2 for $1,517.26.

The retrofit kit parts by EMD for dash two model locomotives are listed below.

Kit Part No. 9524245:

Part No.	Quan.	Description
9338033	1	Module — DR20
9510430	1	Resistor — RE7
9512761	1	Panel — CADB
9505835	1	Resistor — RE46
8421017	2	Rectifier — CR67, CR68
9514171	1	Nameplate — DR20

Basically, this kit allows the unit to operate at idle and the Throttle 4 position when cooling air is required by the traction motors. The traction motor air supply is sufficient at normal idle (315 RPM) to cool the motors at lower motor field and grid currents (800 amps and 575 amps respectively). When motor current goes above 800 amps or grid current goes above 575 amps, the engine automatically goes to the #4 throttle position. Options for Throttle 5 are available and recommended for prolonged operation in dynamic brake.

The DR20 dynamic brake regulator module has a built-in safeguard to protect the traction motors and grids from overheating. Current levels are regulated at the lower levels if a module malfunction does not raise engine speed to a higher value.

The module also incorporates an enforced time delay of 60 seconds when going from higher engine speed (Throttle 4) to lower engine speed to prevent system cycling.

A number of existing components in the electrical cabinet are no longer needed and may be removed when applying the Two Speed Dynamic Brake Retrofit Kit.

The DR13 module that must be removed from the unit cannot be modified. EMD recommends the module be kept as a replacement for use on locomotives not being modified.

Some of the existing DR13 wiring on the locomotive can still be used; however, it must be moved or modified. Depending on the procedure used, and the number of locomotives to be retrofitted, an additional quantity of No. 14 cable and Faston tabs will be required. This material must be ordered separately.

Dynamic brake operating time accounts for 9% of the total medium road duty cycle of operation in Reference A.

The new Two Speed Dynamic brake modification can save an estimated 1.1% or 4400 gallons of fuel annually during the dynamic brake mode of operation. These savings are achieved by automatically regulating dynamic brake engine speed approximately 75% of the operating time at idle speed (315 RPM) and 25% of the operating time at Throttle 4 (560 RPM). At $1.00 a gallon for fuel, the ROI on the Two Speed Dynamic brake is less than four months. Annual estimated savings are projected in GRAPH II.

Experience has shown that the Two Speed Dynamic brake installation may result in false reporting of governor problems, therefore, it is recommended that not only Mechanical employees but also Operating employees have knowledge of these retrofits.

Detailed information on the DR-20 module is contained in Section 7 Part D of the EMD Locomotive Service Manuals.

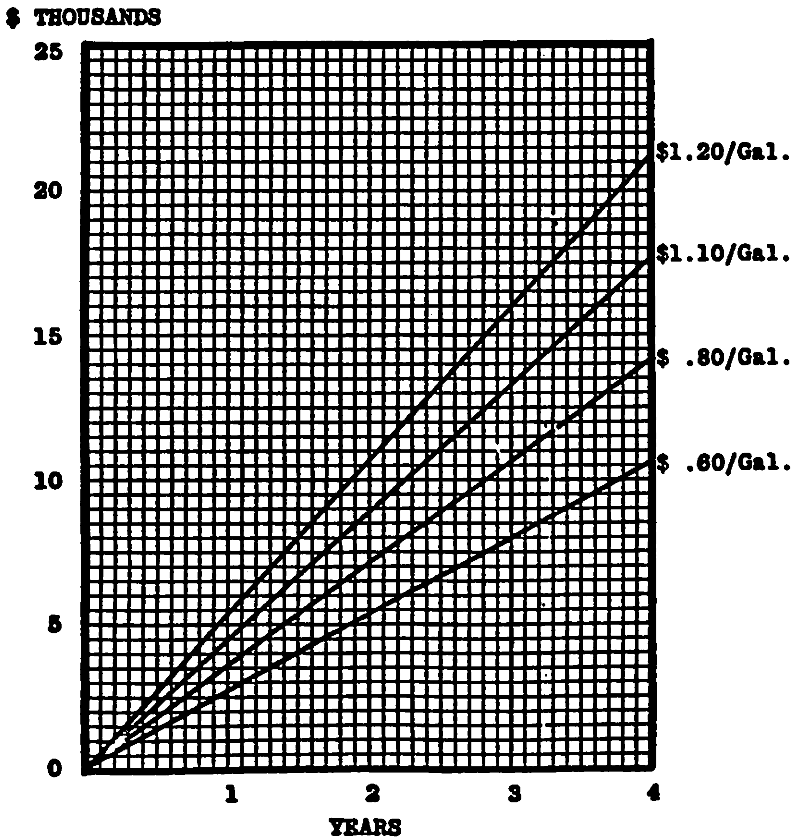
The Part Time Low Idle and Two Speed Dynamic brake can account for 1.8% savings or approximately 7200 gallons of fuel annually. Additional savings can be achieved by using the 200 RPM full time low idle. This may appear miniscule to many; some may even be skeptical of the technical approach by calculation. In order to prove the savings in actual operation, the testing expense will likely consume the savings. A single unit can lose

Quantity	Part No.	Description	4-1-80 Unit Price
A. R.	8472022	Cable-No. 14-500 Ft.	$41.18
A. R.	8250906	Faston Terminal	.07

PROJECTED ANNUAL FUEL SAVINGS

GP40-2 OR SD40-2

The 2 Speed Dynamic Brake produces a 1.1% or 4400 gallon annual fuel savings.



GRAPH II

these small percentages just in the maintenance condition alone, not to mention the fellow on the gas pedal. In spite of these arguments, these electrical changes do provide such savings, whether the unit is tuned or not tuned, or if heavy hands are at the throttle. The challenge and opportunities through the 1980's for continued progress in fuel savings through electrical modifications to locomotives will continue to depend primarily on the builders' innovations. Opportunities of greatest value will be those items that can be done not only to the new breeds of power but also the "existing fleet." Today, existing fleets are eating dollars with heavy auxiliary horsepower requirements for fans, heating, pumps, drives, and small motors. Every small improvement made in these areas will be beneficial. Perhaps one day a means of capturing the heat energies vented through the dynamic brake grids will appear.

D-78 and D-87 Traction Motors — EMD

Thus far, there has been no published information that directly relates to fuel savings gains. The design changes are directed toward improved thermal conditions in the motor. The D-78 designation relates to transposed coils, plus 9% increased copper in the armature, which reduces the eddy current losses when compared with the predecessor D-77 armature.

The D-87 features increased copper in both the armature and the interpole coils. The D-87 should not be mixed with D-78 or D-77 motors on pre dash 2 units. D-77 and D-78 can be mixed universally. The wheel slip controls limit the mixing on D-87 traction motors. Between locomotives there are no known problems. The cost benefits in fuel savings may present themselves in the future, but today these numbers are not available.

Two-Speed Cooling Fans

The retrofit of two-speed cooling fans for EMD units could be made available if desirable; however, the return on investment should be analyzed by individual railroads. At present, information on this modification is limited.

Using a typical GP40-2/SD40-2 equipped with single-speed 8-bladed fan, EMD estimates an approximate 0.8% fuel savings with installation of two-speed cooling fans. EMD Pointer 5L-83 states that additional fuel savings can be realized by unlatching cooling fans and eliminating No. 1 cooling fan operation during periods of idle or dynamic brake. This requires addition of an auxiliary relay, EMD Part No. (MRA) 8363168, and minor rewiring shown in the Pointer. No figures are currently available as to projected fuel savings.

Future Fuel Savings Outlook

The additional papers presented by this committee for the 1984 conference cover the state of art for both GE and EMD locomotives. There is no doubt that the microprocessors will have the most significant contribution toward fuel savings, controlling, performance evaluation, and maintenance scheduling. The changes forecast can be expected to be individual packages, as in this report. Fuel savings of less than 1%, proven only by theory, are expected. Actual fuel testing is limited by cost and accuracies available today.

VII.
PERFORMANCE OF LOCOMOTIVES AFTER STORAGE

Last year this committee gave a paper on preparation of locomotives for storage. Both EMD's and GE's recommendations were discussed along with recommended procedures for short term, long term, stored-unserviceable, and temporary storage.

This year we will report the performance of locomotives after being stored in all categories.

First, we must caution that it is just as important to follow all builders' removal and preparation instructions when returning locomotives to service as it was for storing them.

With a few exceptions, the removal of a locomotive from storage is the reverse of its preparation for storage. It is suggested that a Mechanical and Electrical check-list for locomotive installation be used as a guide. The check-off system will eliminate missed components in need of attention, and inspections can continue on second and third shifts with a minimum amount of delay.

Locomotives returned to service after storage are being monitored by some railroads to establish performance records and increase in cost to operate, if any.

One railroad has a computerized reporting system indicating the type and number of failures on locomotives removed from storage since January 1, 1983. All faults reported on previously stored locomotives are separated from the regular fleet and are illustrated on a percentage bar chart, indicating each kind of fault, number of recurrences, and percent contributed to the total stored locomotives returned to service.

A review of this bar chart indicates some of the major electrical problems on 200 locomotives returned to service.

1. Traction Motors
   54 faults or 9.42%
2. High Voltage (grounds, open, shorts, etc.)
   51 faults or 8.90%
3. Wheel Slip
   48 faults or 8.38%
4. Dyn. Brakes
   42 faults or 7.33%
5. Speed Recorders
   38 faults or 6.63%
6. Power Excitation
   30 faults or 5.24%
7. Dyn. Brake Grids
   23 faults or 4.01%
8. Cab Heater
   16 faults or 2.79%
9. Engine Gov.
   14 faults or 2.44%
10. Low Voltage (wiring problems)
    12 faults or 2.09%

11. Fuel Pump
    10 faults or 1.75%

Electrical faults represent 59 percent of the total 573 reported failures.

Another railroad has been tracking fifty SD-45 locomotives returned to service in June, 1983, after being stored approximately 300 days. They are reporting a 41 percent failure rate on electrical equipment.

Last year we reported that one railroad had been tracking 10 locomotives that were returned to service after being in storage for seven months. This same road has continued to monitor these locomotive placements and releases at all terminals, recording reasons for shopping along with other locomotives returned to service with an average storage time of 555 days.

A review of the shop placements on the 10 locomotives that were returned to service in February and March of 1983 does not indicate any of the reasons for placement that could be attributed to their long term storage.

The locomotives brought back in service in August and September, 1983, after being in storage more than a year and a half, have had 84 recorded faults, 37 mechanical, 42 electrical and five air systems.

Most of the recorded faults could not be directly attributed to the locomotives being stored for a long period of time. However, it is noted that nine of those faults were due to water tank screens stopped up and fifteen were caused by hot diodes and not loading properly. Those long-term stored locomotives now in service will continue to be monitored with an update of total faults when required.

In the past few months many stored locomotives have been returned to service with a minimum amount of delay and cost owing to insistence by locomotive officers that all locomotives stored must be properly prepared with specific instructions issued to meet each railroad's requirements as to atmospheric conditions and length of storage.

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