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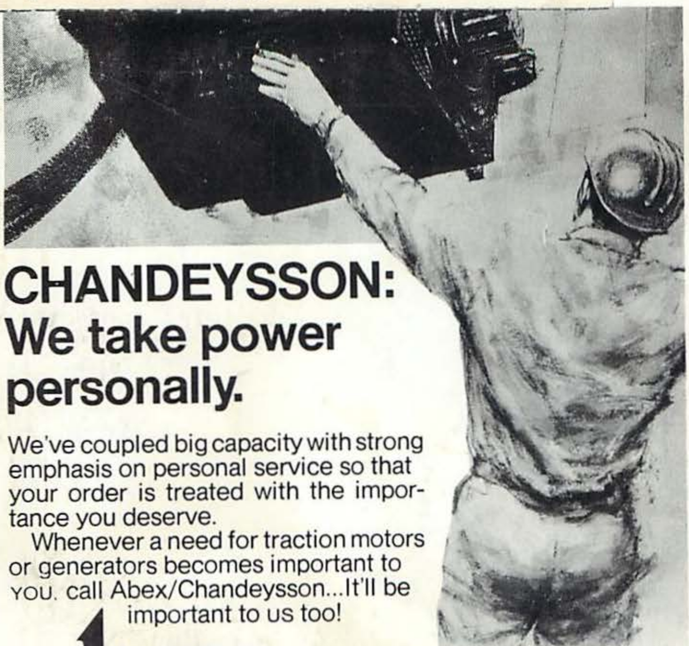

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CONRAD HILTON HOTEL, CHICAGO, ILL.

SEPTEMBER 17, 18, 19, 1979

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Official Discussion Record of 40th Annual Meeting

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MONDAY MORNING SESSION
October 2, 1978

ELDON E. DENT
PRESIDENT
Supt. Motive Power
Missouri Pacific RR Co.
St. Louis, MO

The 40th Annual Meeting of the Locomotive Maintenance Officers Association, held at the Hyatt Regency Hotel, Chicago, Illinois on October 2-4, 1978, convened at 9:30 a.m., Mr. Eldon E. Dent, Superintendent Motive Power, Missouri Pacific Railroad Company, St. Louis, Missouri, and President of the Association, presiding.

PRESIDENT DENT: Good morning ladies and gentlemen. It is a pleasure and most gratifying to see this fine representation here this morning. As President, I extend my personal welcome to each and every one you, and sincerely hope your attendance and participation at this meeting will be meaningful and a worthwhile experience for you and your railroad.

The 40th Annual Meeting of the Locomotive Maintenance Officers Association is now officially in session. The invocation will be given by Reverend David B. Jones, of the Presbyterian Church of

Western Springs. He is an alumnus of McAllister College and McCormick Seminary, and is presently serving as moderator of the Chicago Presbytery. Please stand and remain standing after the invocation.

REVEREND DAVID B. JONES: Before the prayer I would like to share with you what happened yesterday morning in our church. It was World Communion Sunday, and I suspect that many of the churches you are a part of participated in that same event. In our Sunday morning service we have words for children, which means that all the kiddies come forward and gather around me. I was sharing with them the symbols of communion.

One of the symbols was a huge globe. I was talking about the fact that persons around the world would be gathered around the communion table. A little hand went up. "Mr. Jones, are there railroads in all those countries?" He didn't know I was going to be here today. [Laughter]

It gave me a good opportunity at that point to respond about connections, and in the context of the church it was connections with God and with other persons, and obviously today it is the same kind of symbolism in which those of you who are employed in the industry are very concerned about, namely, connections. So, as you come here, I was mindful of my little five-year-old friend yesterday morning who knew that human beings had to be connected somehow. You are helpful in that process. Let's have a prayer.

Dear God, it is a beautiful day, and we gather from many corners of the continent for this meeting. As this convention begins, it begins with an acknowledgement that You, the Creator of the universe, are to be in the midst of the gathering.

We are mindful that there is a sense of dependence, interdependence and independence as we gather this day, that as human beings there is dependence upon You for life and for the resources of life. As human beings there is an interdependence with You as we work in partnership for the fulfillment of life for ourselves and for other persons. There is always a sense of interdependence, but that leads to independence of the ways by which we choose to use our lives, for You have given us that sense of freedom.

As we think about the railroad industry that gathers for these days, we also acknowledge that sense of dependence — dependence for knowledge, dependence for resources, dependence for energy. We are mindful as well of the sense of interdependence. And having come through a week in which we are interdependent for knowledge and technology and persons, for workers, for managers, we acknowledge that we cannot function alone but that we are related one to another.

Finally, there is a sense also in industry of independence, judgements that we make, decisions in

C. M. LIPSCOMB
Secretary-Treasurer LMOA
From 1939 to 1970
Died March 18, 1979

business and in personal lives, the way by which we would respond to You. As this gathering begins, it is our prayer that You will be in the midst of it — You, the Creator of all, and that those who participate in it might learn, might share, might be so inspired that as they return to their homes and places of employment there may be new knowledge in order that we may be better connected one with another.

We pray that this might be a significant time. Amen.

PRESIDENT DENT: Let us remain standing as we pay tribute to our members who have departed this life during the past year.

JACK GOODWIN, C & NW

BILL DePOYSTER, ICG

Thank you, gentlemen. Please be seated. Thank you, Reverend Jones, for your inspiring message.

At this time I would like to introduce Mr. John W. Ingram, President and Chief Executive Officer, Chicago, Rock Island & Pacific Railroad Company, Chicago, a railroader since his student years when he held a summer job as a brakeman on the Long Island Rail Road.

Mr. Ingram has served four major railroads as well as the U. S. Department of Transportation in executive capacities. Prior to his being named President and Chief Executive Officer of the Rock Island on November 1, 1974, he was Director of Profit Analysis at the New York Central System from 1955 to 1961. From 1961 to 1966 he was Director of Cost and Price Analysis for the Southern Railway. From 1966 to 1971 he was Vice President for Marketing at the Illinois Central Railroad. In September 1971 he was the Administrator, Federal Railroad Administration.

Born in Cleveland, Ohio on April 6, 1929, Mr. Ingram received his Bachelor of Science degree in Business Administration from Syracuse University in 1952 and a Master's degree in Transportation Economics from the Columbia Graduate School in 1955.

Mr. Ingram has made it an article of faith on the Rock Island that all phases of the company's activities be totally user oriented. "The only way we earn money is providing services, and ours is one railroad where shipper needs come first."

It gives me a great deal of pleasure to introduce Mr. Ingram. [Applause]

MR. J. W. INGRAM [President, Chicago, Rock Island & Pacific Railroad Company, Chicago, Illinios]: I want to thank you very much for the opportunity to be with you. It is always nice when Rock Island people are invited out. We are all pleased by that. First of all, Rock Island people are always flattered to be invited to speak anywhere. Whether it is literally true or not, we consider such invitations to be testimony to the Rock's continued importance within the industry, and it makes us feel good.

JOHN W. INGRAM
President and
Chief Executive Officer
Chicago, Rock Island and
Pacific Railroad Co.
Chicago, IL

Secondly, I am delighted to talk to locomotive people. You know, locomotives have been the keystone of Rock Island's turnaround activity. We sort of felt that the first priority in rebuilding the Rock was putting the locomotives back into shape. The second priority is cars, and the third priority is the track. If you don't have anything to pull it with, a car fleet alone isn't going to get you any business. No matter how good the track is, if there isn't something to pull trains on it there is no way to make any money.

That is the order of our priorities. We are delighted now that we have much of our rebuilding behind us. We have more to do, of course, but the average age of Rock's locomotive fleet is now 7.9 years, and we are very pleased with that. That is much better than what we had when Frank Findling first went to work on the sizable challenge back in early 1975.

Incidentally, I hope I am not taking advantage of your invitation by doing a little cheering for the home team, but I think Frank Findling deserves the recognition of his colleagues and counterparts for what he has been able to do for us at the Roc. He and Dennis Waller and any number of other master mechanics and and good people have done things that they never expected to be called upon to do. They have achieved the impossible so regularly that it is now almost routine. They have worked themselves into and around the Rock's financial limitations so well that they remind me of that old motto of the Seabees: "We have done so much with so little for so long that pretty soon we'll be doing everything with nothing."

Frank and Dennis, we still have many challenges ahead, and probably a few more arguments, but I want you to know that the fact that you are both still gainfully employed is not an oversight. In fact, we highly value your loyalty and your tolerance, your spirit, and most of all your ability to make those engines run.

Having said that, Frank, let me remind you again in public that our locomotive maintenance cost per ton-mile of freight carried is still a little too high, and I expect you either to bring that cost down or increase our carloadings. Better yet, do both.

At any rate, we at the Rock care very much for our locomotives — so much, in fact, that we name them for politicians and shippers and anyone else we think may be flattered by it. It helps, but I must admit that EMD seemed a little concerned when we told them that one of our GP38s was to be delivered with the name "Ivan The Terrible" painted under the cab window. I think Pete Hoglund worried that the name might be a reflection on his product, or perhaps that the Rock had finally gotten political support from a very authoritarian quarter. The truth of the matter is that "Ivan The Terrible" is the nickname of one of our most valued shippers. He loves to pose for photographs next to "his" engine whenever it gets up in that part of northwest Iowa.

In keeping with protocol keynote speakers must follow, it is time for me to stop talking about the Rock and devote myself to a few generalities of interest to you all. I am not going to be all that general. I have five very simple, specific suggestions and then we can get this keynote speech over with. In fact, you might call them fervent pleas. I submit them for the consideration of both locomotive manufacturers and locomotive maintainers.

First, let's get rid of FRA locomotive inspectors. How does one do that? Well, I think American railroads really ought to have sharp-looking locomotives. I think they should be very classy; they should be clean; they should be shiny; they should be machines that command respect and imagination and admiration.

Once they do look great, inspectors are not going to concentrate on the trivia that they sometimes overly worry about, but rather on the important safety factors that we all want them to check. When the trivia starts being properly ignored because the locomotives are clean and in great shape, and the major potential dangers are regularly being caught by our people, we will have no longer that serious adversary relationship that we have today. Those fellows will still be around, but they will be our friends rather than our enemies.

While we are at it, I think somewhere in that great repository of American ingenuity there must be someone who can invent a machine to clean a locomotive, a locomotive washing machine that is superior to anything we have today. I am tired of being told that the only way to wash the sides of a locomotive is by hand.

My second suggestion ties in with cleanliness. I think it is high time the manufacturers of diesel engines learned how to build things that don't leak oil all over the place. Caterpillar Tractor down in Peoria makes tractors that don't leak oil; Mercedes knows how to do it, and I understand even Cadillac now has a diesel on the market. I haven't seen one, but I suspect the Cadillac diesel does not drip oil on the country club driveway. I am sick of locomotives that look like fugitives from an explosion at an oil refinery. I think it is within the capability of American industry to design an engine that will take care of that problem.

My third suggestion (and this ought to be easy) is that I want speed recording devices (and you could break with tradition and call them "speedometers" if you like) that are built to be at least as accurate as those on the Ford Pintos. I want them to be easy enough for a vocational high school student to maintain and adjust, and I want them secure enough so that they can't be tampered with by my friends who run locomotives. I get very uneasy when my chief engineer complains about trains exceeding track speeds. The chief operating officer tells me the speedometers are no good, and the CMO tells me that we've got the best junk that's available at a decent price. Let's fix that and let's fix it now.

Fourth — and this is a larger challenge because it requires thinking, and thinking makes the head hurt — I would like to see locomotives designed with modular subassemblies on skids. I am not talking about plug in-plug out gimmicks in the electrical compartment, although I think they're great. I am talking about prime movers, generators, blowers and other major components that nowadays require raising the roof, as it were, before you can even start work.

We pay half a million dollars or so for these things for the sole purpose of moving freight. We do not buy locomotives in order to keep shops busy. I would like to see design perfected to the point that a full generator changeout takes about 45 minutes. I would like to see engine replacement done in 90 minutes. There is no logical reason why locomotive subassembly changeouts should take any longer than changing an engine in a Volkswagen Bug. The only difference is size, and we all have heavy equipment capable of handling our larger hunks of machinery—and if we don't have it we can get it. The idea of tieing up a half million dollar-plus locomotive for three or four days to change out some part, or to fool with some defect rather than just changing out the offending piece of machinery and then getting the locomotive back on the road, and then repairing the defect in the shop, is just beyond me.

My fifth suggestion probably falls into the category of heresy, but I'll make it anyway. I think every CMO should take it upon himself to strike up friendships with counterparts in other industries, especially aviation. I would hope that sometime during the next year everyone in this room will arrange to visit either United Airlines in Chicago, TWA in Kansas City, or American Airlines in Tulsa to see what they do with their motive power. See how fast they get their babies out of the "house" and back into revenue service. For that matter, check the maintenance shops of some of our better trucking companies. You will find that the really good ones are miles ahead of us, not just in layout and facilities but also in attitude and philosophy, which of course is what they are all designed to do.

Frankly, gentlemen, I could go on for a while longer talking about locomotives and how we all use, abuse and reuse them. They are, as I am sure all of you agree, the keystone of everything we do. After all, if we didn't think that, why would we be highlighting our power right in the center of a very expensive advertisement in this morning's Wall Street Journal?

Again, I want to thank you very much for inviting me here. I don't think it is necessary for keynote speeches to go on forever. I hope you have success in your meetings. Enjoy your deliberations and productive results. Keep those engines out on the road moving freight, which is what the story is all about.

Thank you very much.
[Applause]

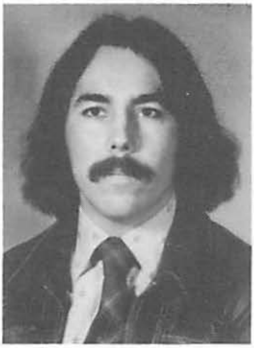
PRESIDENT DENT: Thank you, Mr. Ingram. As a former FRA Administrator and presently the president of one of our great railroads, your points are well taken and sincerely appreciated. Many thanks for your fine talk.

We of the LMOA most sincerely appreciate your taking vacation time to be with us at this meeting. We hope you will come back to keep us up to date on the trends of the times. We would like to make you an Honorary Life Member of the LMOA. Emblematic of this membership is this pen and pencil set for your desk. We appreciate your being here.
[Applause]

During the past few days intensification of the strike certainly had an adverse effect on attendance at our meetings. We are aware of the responsibilities, and regret very much not having with us today many attendees who might very well have been with us otherwise. We are deeply appreciative of you who are able to be with us now. I hope your enthusiasm and response to these presentations will more than make up for the lack of attendance.

MONDAY MORNING SESSION
October 2, 1978

REPORT OF THE COMMITTEE ON NEW DEVELOPMENTS



CHRIS W. COX, Chairman
Locomotive Gang Foreman
Santa Fe Railway Co.
Argentine, KS

E. T. HARLEY
1st VICE PRESIDENT
Director - Operations Technology
Consolidated Rail Corp.
Philadelphia, PA

At this time I would like to call on Mr. Tom Harley to come forward and be the officer of the session. Mr. Harley is First Vice President of LMOA and Director of Operations Technology with Consolidated Rail Corporation.

MR. E. T. HARLEY: Thank you very much, Eldon.

I would like to ask Chris Cox and his Committee on New Developments to come forward, please.

Our first presentation at this 1978 session will be the report of the Committee on New Developments. The chairman of the Committee is Mr. Chris W. Cox, Assistant Roundhouse Foreman of the Atchison, Topeka & Santa Fe Railway Company, Kansas City, Kansas.

[Mr. Harley introduced Mr. Cox. Mr. Cox then introduced the members of his Committee. The report was presented by Mr. Goehring, Mr. Whittle, Mr. Crandall and Mr. Cox.]

MR. COX: I would like to thank you for listening to our presentation. We will now open the meeting for discussion of the various topics and will try to answer any questions you may have.

MR. R. W. LEEDY [Contract Administrator, Illinois Central Gulf Railroad, Paducah, Kentucky]: I have a two-part question. Concerning the amber lights, do you have any idea what the average cost per locomotive application would be? Are we faced with a deadline or some kind of ruling that says we have to have these lights? I know there is a congressman in Illinois who has talked about these lights in Congress. Do you have any information on that?

MR. DAVID G. GOEHRING [Manager Maintenance Planning, Amtrak, Washington, D. C.]: It depends on whom you talk to as to how much it will cost to apply a strobe light system on the cab of a locomotive. It will range from $250 for material plus $50 for labor up to a total of $800 for labor and material. I cannot answer your question as to what the exact cost is. My guess is that the average installation cost for a strobe light system that is activated by the bell and horn would be $400 to $500 for labor and material if done in the railroad's own shop.

Concerning the rotating amber beacon, a continuously operating light, the cost of application would be considerably less than that of a strobe light system. First, the material is less expensive; second, there is no interface with the horn and bell but only an on-off switch which permits the beacon to operate continuously. The installation cost would be limited to running conduit from the light to a power source.

The state of Washington already requires that locomotives have a warning light other than a headlight. Their law specifies the rotating amber beacon. At present, Amtrak is able to operate strobe-light equipped locomotives in the state of Washington with the stipulation that the lights be operating continuously. Why continuously operating strobe lights are necessary, I don't know. I do not know what other states may be planning. I do not know what the federal government is planning.

The reason tests with strobe lights are being conducted and sponsored by FRA is to determine if strobe or beacon lights mounted on locomotives will reduce the probability of railroad-grade crossing accidents. To date, the tests have not been conclusive and are still going on.

MR. FRANK B. FINDLING [Chief Mechanical Officer, Chicago, Rosk Island & Pacific Rail-Road Company, Chicago, Illinois]: Is there anyone here from the AAR? I spoke to the AAR about these strobe lights. I am nonplussed because we are paying for the AAR. We are all members of the AAR. They knew very little about what was going on. I talked to Frank Danahy. He said it is still in the embryo stage and it has to be reviewed further by the FRA and then they will probably get the AAR into it, but the AAR is not into it as yet.

Gentlemen, we have here a relatively bad situation that I want to call to your attention. The same thing has occurred with rear-end markings on freight trains. I am not saying this in order to chastise any railroad in particular, but I just want to bring to your attention that as chief mechanical officers and mechanical officers there is a table of organization through which you operate. You certainly don't want your man running around you and talking to somebody who has an ancillary service relative to your operation, rather than talking to you yourself.

The same thing happened with the rear-end markings. Some railroads just moved right ahead and started to test rear-end markings and submit them for okay without even discussing them with the AAR.

The AAR is our soundingboard. If they are our representatives to the FRA we should clear things through them. If you don't want them you should get rid of them, and then deal directly, and then we will have the same hodgepodge we have had in many other areas. We have got to have a unified, organized review of these items that are brought up on the FRA so that the necessary action can be taken and everyone else can be kept informed. So much for that.

The fact remains that the AAR knows very little about the tests being conducted by the FRA, and I think it behooves the railroads making these tests to submit joint reports, if they must submit them to the FRA, and include the AAR in their findings.

I called the AAR because we had been making our own tests relative to crossing accidents, and we had been using blue strobe lights on top of our locomotives both in switcher and road service. We had made this test in our Des Moines yard and had also applied the tests to two of our road trains operating out of Des Moines.

In order to determine whether the type of equipment we were using was proper, we called in the state police. We had a Major from the state police come down and inspect our equipment, which incidentally included two lights mounted on a crossbar similar to those on police cars, with each light at the inside edge of the cab roof — one light on each side of the cab roof. The results were rather remarkable. For one thing, at night, people coming up to a crossing that was protected or unprotected could look down the road and see a blue light in that area, a light similar to that used by the local police. It certainly causes them to stop, and we have had no reports of anyone crossing in front of trains so equipped.

I thought I would add this information to what you have now, with the hope that other railroads will share their ideas, too. Let's all get into the act, but let's all work together.

Thank you.

MR. C. W. COX [Assistant Roundhouse Foreman, Atchison, Topeka & Santa Fe Railway, Kansas City, Kansas]: Mr. Findling, thank you for your comments. I can only agree with you that it is important that we work together as a group, and not try to make rules or regulations from tests or information derived from a few of our members.

MR. LEEDY: I would like to follow up on that with something else that may be of interest to Frank. Here again this is in the Federal Register.

I understand that by mid-1980 all locomotives are going to have to be equipped with exhaust silencers. I don't know how many of you in the audience are familiar with this. It may be something for your Committee to develop. I understand EMD is going to do this with their new model. I would like to ask Walter Weck if he would comment on that.

MR. WALTER WECK [Assistant General Service Manager, Electro-Motive Division, LaGrange, Illinois]: Bob, I know there is a deadline, and I know there are indeed silencer applications in the field. This Committee talked about silencer applications to the Amtrak SDP40F locomotives in the past. This application was for the turbocharged locomotives. There also was an application for the non-turbocharged locomotive. You are correct, these silencers will be available to meet the deadlines as specified, and will meet all requirements. That particular phase of the law will be met.

MR. F. I. BURCHETT [Mechanical Assistant - Locomotive, Atchison, Topeka & Santa Fe Railway, Chicago, Illinois]: I would like to clarify one fact before we go off too far here. There are two proposed laws. One of them pertains to noise emmision or exhaust silencers, and another one pertains to the strobe lights. These are written in the Federal Register only as proposed laws.

It is our responsibility as members of the railroads and the AAR to answer these proposed laws and get in there and tell them what we can do and what is possible. People writing these proposed laws need more familiarity with what is capable of happening, rather than going into some of these environmental laws that we see and that we have had to back away from.

Another one we are going to see is going to be on windshield and side window missile resistance. A supplier or someone can start some kind of a test and tell you how great his product is even though it has never been tested. So, we as railroad people and members of the AAR must read the Federal Register and answer these things.

On our railroad we have answered every one these proposals, in particular the one on the strobe lights, and the FRA proposal. We have answered the one on noise emission. So, be careful. These are only proposed laws, not laws in effect.

MR. COX: That point can't be overstressed. We hear somebody sit back and gripe about a law, but that person has nothing to stand on if he never made any effort to change it before it became a law. We should all strive to work as a group and make things known as they should be.

VOICE: I appreciate Mr. Findling's remarks on this matter. I think we might all look at our own railroads. In the case of strobe lights and also warning devices, horns, and so on, which our own safety departments are taking a lead on in this area, I think it will behoove us as mechanical people to work a little closer with the safety department. I know our safety department on the Union Pacific has a group of people meeting in Chicago today, and it might be possible to bring this to all of our safety departments on the various railroads, to make certain that we do work with the AAR in this area.

MR. BURCHETT: A couple of comments were made in Bill's portion of the paper, and Chris followed through well on them. Bill talked about fuel savings and comparisons between experimental locomotives. I hope these experimental fuel saving tests are going to be compared with Plane Jane so we know how much fuel savings we are making over Plain Jane. We have been operating some test locomotives. Fuel could be one of the most expensive items we have in the future, compared to what we have seen in the last three years with the escalating price of fuel.

There is another problem that could be brought up concerning experimental locomotives, and that is maintenance costs. You say your Committee is going to follow through on these new developments. This could very well be a follow-through of maintenance costs of these new experimental locomotives as compared with the Plain Janes we are operating out there now. There may be a saving in fuel, or the fuel may be more expensive. We don't know today how we are going to compare with Plain Jane, but we need to rationalize and not lose sight of the fact that these locomotives could be very expensive. I would appreciate the Committee making comments on expenses and following through on this. I would like to hear their comments.

MR. COX: At this time we don't have any information regarding the fuel savings or whether any particular test locomotive has more economical fuel consumption for power output. The point we wish to make is the importance of accurate measurement in regard to fuel consumption tests.

It was mentioned by Mr. Burchett, and we would like to state it again to make sure we all realize that at the onset of the energy crisis we were all probably a little guilty of getting strung out a little too far on test results regarding fuel savings.

The most important point we wish to make as a Committee is that the type of tests used, the type of measuring equipment used, and the type of tests formed should be valid and accurate. We continue to request that search for and tests on new model locomotives or any comparison tests be required to prove the accuracy of the results.

MR. T. L. WESTERFIELD [Electrical Engineer, Chicago and North Western Transportation Company, Chicago, Illinois]: Along that line, there has been in some published reports (particularly one from the FRA) concerning over-the-road fuel savings compared with systems, things about reliability of fuel measuring equipment. Has there been enough testing of the schemes in the paper to establish their reliability over a long term, in terms of having the equipment working from one end of the run to the other?

MR. COX: Yes. I think there has been some relatively long-term testing with the two types of systems. I would like to ask Mr. Whittle to discuss some of the reliability of the equipment that is now being used.

MR. T. C. WHITTLE [Manager Product Planning, Locomotive Products Department, General Electric Company, Erie, Pennsylvania]: We have been very fortunate in being allowed to work in conjunction with Conrail in the development of our equipment. I will be perfectly frank. We had the normal infancy problems, some of the relays, and so on, selected that did not perform. As the tests progressed, we have gotten to the point where we have put a set of equipment on board, and it ran five months with 24-hour-per-day operation. The equipment was then removed and returned to Erie. We found it had retained calibration and the accuracy was still there. I can't say we have 100 per cent perfection yet, but we are striving for it.

MR. COX: What type of accuracy are you talking about in terms of percentages?

MR. WHITTLE: As far as repeatable accuracy on fuel, we are well within 1%, and we are very similar to power. People who are familiar with the system we use realize that E cells are normally within about 2%. That is true until you calibrate the E cells. That is why a set of equipment, before we put it on a unit, goes into our engine test facilities. We spend up to two weeks in calibration to make sure we have washed out a lot of the inaccuracies in the E cells. That is why I made the statement that when we brought the equipment back five months later it had retained the accuracy it had when it went out.

MR. BURCHETT: We talked about a previous fuel consumption report, and then a report which followed that indicated there may have been some invalid information gathered. As I have been briefly sketched on the material you are able to gain with your metering

device, you also are able to gain a horsepower hour or ton-mile or some relation to fuel consumption to actually work performed. Is that correct?

MR. WHITTLE: That is correct. We have a very accurate kilowatt hour setup that measures the output of the traction alternator. We don't try to determine what the input to the alternator is, or what fuel is going into the auxiliary loads, because as far as the railroads are concerned you would be well satisfied if either builder could come up with a locomotive that didn't require radiator fans or equipment blowers. Auxiliary load doesn't pull any freight. We decided we would pick a system that can get as close to the tractive effort and power delivered to the rail as we could economically. The best place to cut in was between the alternator and the traction motors. As I said earlier, we have been well satisfied with the accuracy we have obtained.

Our system will tell you the amount of fuel that you burn in idle. It will also tell you the amount of fuel you burn in motoring and dynamic braking. It records the time you spent in idling. Locomotives are sitting around idling 70% of the time, and that is poor utilization. We also indicate how much power goes into motoring and dynamic braking.

MS. MARILYNNE E. JACOBS [U.S. Federal Railroad Administration, Washington, D.C.]: Mr. Whittle, you mentioned that the accuracy was 1% on your metering system, is that plus or minus 1% or .5%.

MR. WHITTLE: It would be plus or minus 1%.

MS. JACOBS: The FRA is currently looking over a variety of fuel metering systems, and we would be very interested if you had any cost data on your particular system plus recorder.

MR. WHITTLE: Actually, our equipment is not for sale. We will have by the end of the year ten sets of equipment that we will have available for use by railroads for the type of testing they will want to do. I can give you an order-of-magnitude figure. It will fall someplace above $6,000 and less than $10,000.

MS. JACOBS: It sounds terrific.

MR. WHITTLE: It is very difficult to put a dollar sign on prototype equipment that you are not intending to put into production. You do not set up to get your costs down.

MS. JACOBS: I have another comment if there is time. The FRA is currently developing another microprocessor on-board recorder similar to what you have described today. The difference is mainly in the accuracy of the total work output and various time accumulations.

We do accumulate data to form histograms of time versus throttle position and total work output both electrically and by measuring drawbar pull. We are going to be doing some field testing in the spring, and we would welcome the opportunity to present our results to this Committee, particularly in the transducer area.

MR. COX: Thank you. We would be very interested.

VOICE: Will you please explain why random sampling will offer a more economic and effective surveillance system for train operation recording systems?

MR. COX: I think the point that should be remembered is that the effectiveness of this system will be good only if the information received from the system is followed through all the way down to the train crews. Anybody can generate a pile of data and can make a system and say we have a train operation recording system, and look at what we are recording. But to use the system properly you have to got to take that information right down to the train crews and the maintenance people, and make sure the information is brought back to them if we are violating speed rules, if we are over-maintaining or under-maintaining locomotives, and so on. The people at the operating level have to know.

This is why a random sampling would be better, because with the system of generating every detail of everything that occurred on a railroad 24 hours a day you would have too much data. But to do it on a random sampling basis you would cover a lot of territory, and even the people who were being monitored would not know that at the time, and they would try to maintain proper operating rules and proper maintenance on the mechanical side. That is why it would be more cost effective.

MR. J. H. LEHMAN [Assistant Engineer - Shop Machinery, Illinois Central Gulf Railroad, Chicago, Illinois]: I have a technical question on the EMD fuel measurement system. This is the second time this particular system has been presented. It was covered in the publication last year under the Fuel and Lubricating Committee's presentation on fuel measurement.

This year there are two changes in that schematic. One is a 10 lb. pressure relief valve in the fuel return system, and the second is the addition of a strainer. Could you please explain why these additions were made and what purposes they serve?

Another point is that there is only one way out of this system, and that is through the injectors. When the system is installed on a locomotive and first needs to be purged of air, how is this accomplished and how reliable is it?

Also, if this system is ever installed as a permanent application, has EMD given any thought to where they would put it?

MR. WECK: I will start with the third question. No, it has not been installed as a permanent sysstem. No, the intent is not to be a permanent system. As you could gather from Mr. Whittle's remarks, it is a test tool to accurately measure fuel consumption, and does not contain all of the building features discussed previously. It must be used in conjunction with a throttle position counter, ammeter-voltmeter, to determine power, and so on. So, you can see it is just a single portion of the entire picture. It is how to more accurately measure fuel.

To answer your question on the filter, it is quite necessary that we do have clean fuel. You gentlemen are familiar with what is happening with fuels.

I would like to sound like an expert. We have Mr. Dunteman here, who may be just that expert.

MR. RICHARD DUNTEMAN [Engine Design Section, EMD, LaGrange, Illinois]: I believe I can comment on the question regarding purging, and also the question regarding the check valves, as they are both in the same area.

The purpose of the check valve is to keep the system full and try to minimize the amount of air. Once it is bled by the use of a petcock on the top of the heat exchanger unit, it will remain free of air. In fact, we have run these systems for upwards of a month in revenue service without any maintenance of any kind on them. One of the reasons for the addition of the strainer was to keep minute particles from perhaps the installation of the device itself from getting into the positive displacement flowmeter which has very tight clearances.

Are there any other questions with regard to the system?

MR. LEHMAN: We have installed some of these systems and they have appeared to function quite well. You mentioned a positive displacement flowmeter. Which meter are you using?

MR. DUNTEMAN: We have a Neptune positive displacement flowmeter very similar to what would be used for a water meter in a house installation.

MR. WHITTLE: As is obvious, this is one of the advantages of having LaGrange just 18 miles from Chicago. [Laughter]

MR. E. T. HARLEY [Director-Operations Technology, Consolidated Rail Corporation, Philadelphia, Pennsylvania]: I have a couple of comments to make on one of the subjects brought up earlier. One was the subject of federal rulemaking in the area of locomotive noise emissions. There are some fairly recent developments in that area that I think you probably should be filled in on.

As far as the locomotives and their noise standards are concerned, my understanding of the present regulation is that locomotives built after December 31, 1979 (which is about 15 months hence) will be required to emit lower noise levels, and every locomotive built from that day on will have to be built to a lower noise level.

The rulemaking does not state, however, the method by which that noise reduction will be made. It does not, as I understand it, state that mufflers will be used. It does not state that it will be done by the insulation around the engine

compartment. However, it will be done in some manner. It includes noise reductions not only in full throttle but also noise reduction in idle.

The current area of AAR involvement with the FRA in noise rulemaking is in the area of fixed facilities. This does not refer to locomotives and cars out on the line of road. This refers to noise crossing the boundary line of fixed facilities such as yards and enginehouses and even things such as coal dumpers which may be associated with railroad operation.

The EPA was taken into court by the AAR because they had not promulgated regulations in the area of noise levels emanating from these fixed facilities. They did promulgate regulations in the area of noise emissions from locomotives and cars on the line of road, but not fixed facilities.

The AAR's legal people and the attorneys representing the railroads felt that the failure of the EPA to preempt local municipalities and states from rulemaking in the area of noise emanating from fixed facilities such as yards represented an area which was mandated by Congress, and apparently they got a federal court to agree with them that this was indeed true. So, the EPA was ordered by the court to come up with rules by last month. This has since been extended by six months by agreement between the AAR and the EPA and the court whose jurisdiction this case came under.

In the meantime, maybe some of you have seen the agents of the EPA mostly in the firm of Bolt, Beranek & Neuman, the sound measuring firm. They have gone to a number of yards around the country. Conrail has had measurements made at Enola Yard, Frontier Yard and their Allentown, Pennsylvania facility. It is hoped that with the data obtained from these sound measurements we will be able to have some rulemaking which is meaningful and something we can live with.

It may in some instances require that you make some physical changes in your facilities. If you have a locomotive storage track that is right next to the property line, it may well be that while these locomotives idling do not produce real high noise levels, they do produce noise levels over long periods of time, and the type of measurement used here is the LDN, LIO or LEQ systems. These noise measuring systems measure sounds over a long period of time, such as 8 or 24 hours. A locomotive idling for a long period of time can create a significant amount of noise even though the intensity of that noise is relatively low. So, there may be cases where you may have to do some things like move locomotive storage tracks.

Retarders also appear to be a serious problem. I think you are all aware that car retarders emit noise levels that are very high, and it may well require that sound barriers be placed around retarders or that they be modified to produce less noise.

Basically, that is my understanding of the latest noise area, and in six more months there will be further rulemaking and it will cover fixed facilities. This is very much the concern of people in this room, because we can't very well maintain locomotives and operate railroads without fixed facilities.

MR. COX: We are out of time, so I would now like to ask Bud Cumbea to step forward and summarize our paper.

MR. B. A. CUMBEA [Manager Locomotive Data Systems and Procedures, Chessie System, Huntington, West Virginia]: When I first became involved in committee work in the LMOA I made a suggestion that the Regional Executive Officer who was called on to summarize a paper should come up and give a critique rather than say what an outstanding job the committee had done. When I became chairman of a committee I had second thoughts. Now I am in the position of having to give that critique, and I have third thoughts. I found it very difficult to find any criticism with this paper today.

B. A. CUMBEA
REGIONAL EXECUTIVE
Manager Locomotive Data Systems & Procedure
Chessie System
Huntington, WV

There is no question in my mind that microprocessing equipment will lead to expanded analytical techniques for diagnosing locomotive problems. Advances in this type of equipment are being made at such a pace that some of the equipment on drawingboards is obsolete before it goes into production. Also cost will be reduced to the point that economical justification can be easy. This was evident from the remarkable reduction in cost of the small calculators everyone is familiar with.

Protection of the public at grade crossings will continue to be a problem until such time as the general public becomes aware of the dangers of ignoring warnings and trying to beat the train to the crossing. Better efforts in education should be accelerated.

Fuel conservation and measurement devices can be put in the same categories as micro-computers. The development of reliable economic equipment for measuring fuel consumption is just around the corner. This can bring about an entirely new approach to establishing maintenance schedules and policies.

Recording of events in train operation certainly fits in that category and offers the maintenance officer another tool for combatting problems and improving on-the-road performance.

Locomotive builders are offered a challenge in the final section and will be offered more challenges in papers yet to come. We sincerely hope they will continue to heed these challenges and continue their efforts in new developments.

I might close with a little story told in Huntington when this paper was presented. Milt Crandall stumbled over the Sulzer engine. We understood at the time the engine was going to be put on an Alco frame and therefore would be known as an Alco-Sulzer. [Laughter]

The Committee has done an excellent job in presenting the paper and fielding your questions, and we thank them very much for their presentation. [Applause]

PRESIDENT DENT: Thank you, Bud.

Just a few acknowledgements and announcements. The North American railroads are regulated by governing bodies which are in attendance here today. At this time will the representatives of the Federal Railway Administration please stand? [Applause] From Canada come representatives of the Board of Transport Commissioners, and we would ask that they please stand. [Applause] Are there any representatives from Mexico or any other foreign country present? If so, will you please stand and identify yourselves? [Applause]

VOICE: I hope you don't consider Canada a foreign country. [Laughter]

PRESIDENT DENT: On behalf of all of us in the LMOA, I would like to express our most sincere appreciation to the suppliers who support our organization through their advertisements and associate memberships. We feel that your advertising investment goes farther with us, and your message is certain to be before the people who really count for you — our total membership, which includes presidents, vice presidents, chief mechanical officers, purchasing officers, and general managers of our railroads.

It is a pleasure for me to pass on to others the names on our Advertisers' Honor Roll. If by chance your company's name is missing, won't you please exert a little effort to have it added before the end of the year, in time for placement in our coming Annual Proceedings book? Needless to say, without the good help of you supply people we would not have been able to carry on and progress as we have.

Also, we wish to thank Marty Hausmann of Power Parts Company and his representatives for their great help and assistance in hosting our committees in their pre-convention presentations, regardless of time or location. Mr. Hausmann, please take a bow. [Applause] Likewise, Mr. Eckerle of Nalco Chemical Company for years has hosted our official family luncheon on the opening day of our annual meetings. Mr. Eckerle, will you please stand and take a bow? [Applause]

Through the years the success of this Association has been made possible by the efforts of many capable and dedicated people. We are most appreciative to each of you for your support, and we extend our sincerest thanks.

We request that everyone stay out of the supply meeting rooms while the meeting is in session. While you are out among the people, enroll as many supply members as you can so that we can build up our membership.

We will reconvene at 2 p. m., and urge that you be present to hear the reports.

Now let's give a rising vote of thanks to Chris Cox and his outstanding Committee.

[The audience arose and applauded.]

[The meeting recessed at 11:40 a. m.]

MONDAY AFTERNOON SESSION
October 2, 1978

The meeting reconvened at 2 p.m., Mr. E. E. Dent, President, presiding.

PRESIDENT DENT: In thanking those who so willingly give of their time and support to the good of our organization, much credit must be given to our Mr. Tom Shedd, of Modern Railroads. Thank you, Mr. Shedd. Mr. K. G. Ellsworth, of Railway Age. Also, Mr. Richter, of Progressive Railroading. Let's give them a big hand. [Applause]

The What's Your Problem session Wednesday morning will be very informative. It has been suggested that you turn in your questions at the end of this session to me or any of the Vice Presidents here at the table.

A year ago I stood before you and made a couple of predictions. The first was that our Association's accomplishments during the year would be your accomplishments, much more than mine. That was a safe bet — as I knew it would be — for you have performed admirably.

My other prediction — that you of our LMOA team would back me up during my year as President — also has proved true. I thanked you then in advance for your support, and I thank you again now.

This past year continued an LMOA tradition. It was yet another year in which our Association benefited from good use of the People Resource. Individually and through the work of our committees, we have seen effective exercise of the People Resource in the form of brain power at work. I would like to share some thoughts with you today about the importance of the People Resource, the importance of brain power.

We all know that vast amounts of capital will be needed to maintain, improve, modernize and expand the railroads' physical plants and freight car and locomotive fleets for the demands of the future. But I believe people and their brain power are even more productive — even more important —than money power. Because *it is* People who cause things to happen. If, as locomotive maintenance officers, we are to continue to help our industry regain its dominant role in transportation, we need to be creative problem solvers in meeting our challenges. Above all, we need enthusiasm.

Perhaps the most important lesson to be learned from the past is that we must not become complacent nor dare to limit ourselves to the use of knowledge or practices gained in the past. Instead, we must create — we must innovate — we must think.

In preparing my remarks for today, I came across some quotes that fit the brain power theme. Oliver Wendell Holmes said, "Whenever a man's mind is stretched with a new idea, it never returns to its original dimension." Tryon Edwards wrote, "Thoughts lead to purposes; purposes go forth in action; action forms habits; habits decide character, and character fixes our destiny."

Finally, this one from an unknown source: "The probable reason some people get lost in thought is because it is unfamiliar territory to them." Not true, I say, of LMOA people.

To cope with the challenge of our future — three major ones are dwindling energy resources, environmental concerns, and unprecedented growth in traffic — we as locomotive maintenance officers will need to possess an ever-widening store of knowledge and skills. We will have to improve productivity, stretch and creatively use our physical resources, even further improve equipment reliability, and do all we can to extend the utilization of motive power.

We will no doubt find more and more ways to use computers. Above all, we will have to become even better planners.

New ideas and new systems bring with them new challenges and new opportunities. As locomotive maintenance officers and members of LMOA, we are cast in a role that provides us an excellent opportunity to advance our industry and strengthen our American economic system.

I have heard it said that if there is one thing railroaders lack, it is inquisitiveness. I don't believe that. We know the complete opposite is the case. But we must remember that none of us can afford to accept the present methods as sacred. That doesn't mean that we must scrap all proven ways of doing things. But it does mean that we must maintain a constant review of our methods and apply new, creative solutions as required.

The challenge we all face from our various managements is to help solve the transportation needs of our customers. The future of our industry depends to a great deal on our ability to innovate and make changes rapidly enough to satisfy these needs.

In closing, I urge the following for all of us of LMOA: Let us continue to be a group that is not bound to traditional methods. Let us continue to look forward — to turn over rocks — to cooperate in finding new solutions and new methodologies — to broaden our horizons. And above all, let us not spend too much time listening to a Past President lecture to us at the expense of working sessions.

I thank you for my year as your President. [Applause]

Now I would like to call on Vice President Nelson Buskey to act as officer of the session. I think it would be well to recognize the Vice Presidents of our organization here at the front table.

Mr. R. R. Holmes, of the Union Pacific. Mr. N. A. Buskey, of the Chessie System. Mr. J. H. Long, of the Chessie System. Mr. E. T. Harley, of the Consolidated Rail Corporation. Mr. R. G. Clevenger, of the Atchison, Topeka & Santa Fe. Mr. Frank Bruner, of the Union Pacific, Darrell M. Walker, of the Southern Railway, Past President Ky Pruchnicki, and Advisory Board Member Frank Findling, of the Rock Island.
[Applause]

MR. NELSON A. BUSKEY [Superintendent Locomotive Department - Operations, Chessie System, Huntington, West Virginia]: Thank you, Eldon.

Gentlemen, there is some business to be taken care of before the next committee report, so we will proceed as rapidly as possible.

First is the Membership report to date. Railroad membership as of noon today was 1,303, or 205 less than last year. Associate membership, 345, plus 23 over last year. Advertisers, 125, plus 11 over last year. To date the total is 1,768, or 171 less than last year, approximately 9% less.

We want to recognize one railroad that exceeded the 1977 membership, and that is Conrail. I hope you in attendance from Conrail will convey to our good friend Jim Butler, Chief Mechanical Officer, and his Membership Committee our sincere thanks for their fine efforts. Gentlemen, we solicit your membership.

Next on the agenda is the report of the Nominating Committee, which will be presented by Past Chairman of the Board, our good friend, Ky Pruchnicki.

KY PRUCHNICKI
(Retired)
Genl. Supvr. Loco. Maint.
Southern Pacific Trans. Co.
San Francisco, CA

MR. KY PRUCHNICKI [Retired General Supervisor, Locomotive Maintenance, Southern Pacific Transportation Company, Houston, Texas]:

1979 Nominating Committee Report:

President: E. T. Harley, Director - Operations Technology Consolidated Rail Corporation, Philadelphia, PA.

1st Vice President: James H. Long, Manager Locomotive Department, Chessie System, Cincinnati, Ohio.

2nd Vice President: R. G. Clevenger, General Electrical Foreman, The Atchison, Topeka & Santa Fe Railway, Kansas City, KS.

3rd Vice President: N. A. Buskey, Superintendent Operations -

Locomotive, Chessie System, Huntington, WV.

4th Vice President: F. D. Bruner, Assistant Chief Mechanical Officer - Research and Development, Union Pacific Railroad Company, Omaha, NB.

5th Vice President: R. R. Holmes, Chief Chemist, Union Pacific Railroad Company, Omaha, NB.

6th Vice President: D. M. Walker, Diesel Superintendent, Southern Railway Company, Atlanta, GA.

7th Vice President: Kjell Axelson, General Manager, Work Equipment & Machinery, Burlington Northern Inc., St. Paul, MN.

Secretary - Treasurer: J. J. T. Koerner, Chief Accountant - Mechanical, Chessie System, Huntington, WV.

EXECUTIVE COMMITTEE:

R. W. Leedy, Contract Administrator, Illinois Central Gulf Railroad.

W. R. James, General Manager - Locomotive Dept.-Operations, Chessie System.

D. H. Propp, Director of Energy Conservation, Burlington Northern Inc.

B. A. Cumbea, Manager Locomotive Data Systems & Procedure, Chessie System.

Mike Gogol, Chief Quality Control Officer, Southern Pacific Transportation Company.

E. R. Hafling, Assistant Mechanical Engineer, The Atchison, Topeka & Santa Fe Rwy. Co.

J. J. Gregory, Manager-Production Controls, Consolidated Rail Corporation.

MR. PRUCHNICKI [continuing]: Gentlemen, will all in favor of these nominations please raise your hand. Those opposed. It is carried unanimously.

MR. BUSKEY: Thank you, Ky.

It is indeed a pleasure to call Darrell Walker of the Southern Railway System and "Swede" Axelson, from the Burlington Northern, to the podium so we may present their scarlet blazers which are emblematic of the office of Vice President. Unfortunately Swede could not be here today.

PRESIDENT DENT: Darrell, it gives me a great deal of pleasure to present this blazer to you. You have been one of our very hardworking people through the chairs. Not only have you done a great deal of good for us, but you have also helped our satellite club too, the Southern and Southwestern Railway Club. We thank you. [Applause]

MR. BUSKEY: Welcome to the club, Darrell.

Now, gentlemen, it is time to hear our financial status. I will call on our good friend from the Rock Island, Chief Mechancal Officer Frank Findling, to give us this report.

MR. FINDLING: Before reading the financial report, I would like to tell you that this meeting gets more interesting as it goes on. It reminds me of a cartoon I saw on the wall at Lewis College

Newly elected Vice President D. M. Walker, of the Southern Railway, is helped into his LMOA blazer by President Eldon Dent and President-Elect Tom Harley.

when I took my daughter back there yesterday afternoon. It showed a huge ape sitting in the hallway with his arms hanging at his sides. The caption said, "Just when I get to know the answers they change the questions!" [Laughter]

Gentlemen, that is the kind of world we are living in, and I think they are changing the questions because when you run into presidents of railroads like John Ingram, who spoke to us this morning, who raised simple basic questions that we have been kicking around here for years and still don't have the answers to, I don't think we are doing the kind of thinking we should be doing, not just as a group but also everyone associated with us, because we are not as far ahead technologically as we should be in order to make our mechanical department operations less expensive and more efficient. That is something to think about.

And now for the bad news. This non-profit organization called the LMOA is really living up to the description "non-profit." Not only that, but we are being aided and abetted by the federal government. Before I give the report I would like to tell you why I am saying this.

As far as cash income and outgo are concerned, in 1977 we ended the year with a deficit of over $12,000. Over $5,000 of that deficit was due to the fact that we just did not collect enough money, and the other $7,000 deficit was due

F. B. FINDLING
ADVISORY BOARD
Chief Mechanical Officer
Chicago, Rock Island &
Pacific RR Co.
Chicago, IL

to the fact that Uncle Sam decided we were a profit-making organization and therefore taxed us for the years 1973 through 1975, and then added a penalty to it.

Gentlemen, if the recent strike had continued we would have been standing here without our shirts on. I think a reasonable amount of money in savings, and so on, to insure that we still remain viable if such an occurrence would happen when we wouldn't be able to hold this meeting, is what I would call a reasonable amount of money to have in escrow.

That is the end of my comments relative to the report I am now going to give you.

MR. BUSKEY: Thank you, Frank.

And now we will call on our ever hard-working and faithful Secretary, the man who is the heart and soul of this organization, Joe Koerner, who will give his report.

SECRETARY JOSEPH J. T. KOERNER: Thank you, Nelson. I don't know whether you want to hear from me after what Frank had to say. I would like to make just a few comments.

In the past year another LMOA mainstay retired from his railroad and, as a result, from active participation in LMOA. Bill Dadd, having completed an excellent tour of duty in LMOA, from committeeman to Chairman of the Board, will be greatly missed by the LMOA and his friends in it.

Bill was an active and concerned member at all levels of his LMOA career, and his mature judgment and expertise in the diesel locomotive field were ever sought and respected. It's probably also fitting at this time to acknowledge that Bill was highly instrumental

JOSEPH J. T. KOERNER
Secretary-Treasurer

LOCOMOTIVE MAINTENANCE OFFICERS' ASSOCIATION

STATEMENT OF REVENUES, EXPENDITURES AND CASH BALANCES, CALENDAR YEAR 1977

BALANCES IN FUNDS JANUARY 1, 1977:			
Checking Account — Security Bank		$23,192	
Reserve Account — Security Bank		8,415	
Total			$31,607
REVENUES:			
Interest on Reserve Account	$ 440		
Active Membership Dues	7,925		
Associate Membership Dues	3,840		
Registration Fees	2,145		
Advertising Revenues	19,780		
Miscellaneous	52		
Total Receipts		$34,182	
EXPENDITURES:			
Meetings, Convention and Publication	$19,210		
Office Expense, Office Assistance, Supplies, Postage, Stationery and Payroll Taxes	20,038		
Federal Income Taxes and Penalties for Years 1973 Through 1975	6,230		
Interest Paid on Above Income Taxes	860		
Total Expenditures		46,338	
Excess Expenditures over Revenues			(12,156)
BALANCE CARRIED FORWARD TO 1978			$19,451
BALANCES IN FUNDS DIVIDED AS FOLLOWS:			
Reserve Account 1/1/77 Balance		$8,415	
Transfer from Checking Account 12/10/77		1,500	
Interest Earned in 1977		440	
BALANCE IN RESERVE ACCOUNT			$10,355
CHECKING ACCOUNT BALANCE 12/31/77			9,096
TOTAL CASH BALANCE			$19,451

APPROVED:

Eldon E. Dent, President

APPROVED:

Edward T. Harley, Ist Vice President

Approved this 4th day of April, 1978, Chicago, Illinois.

in recruiting me as Secretary-Treasurer of this fine Association. We wish Bill and Margaret many happy years ahead.

To retiring President Eldon Dent, as fine a gentleman as it has ever been my pleasure to work with, my thanks for seeing me through another year. I appreciate it. Although Eldon is retiring as President of LMOA, his valuable contributions to LMOA will continue as he becomes Chairman of the Board.

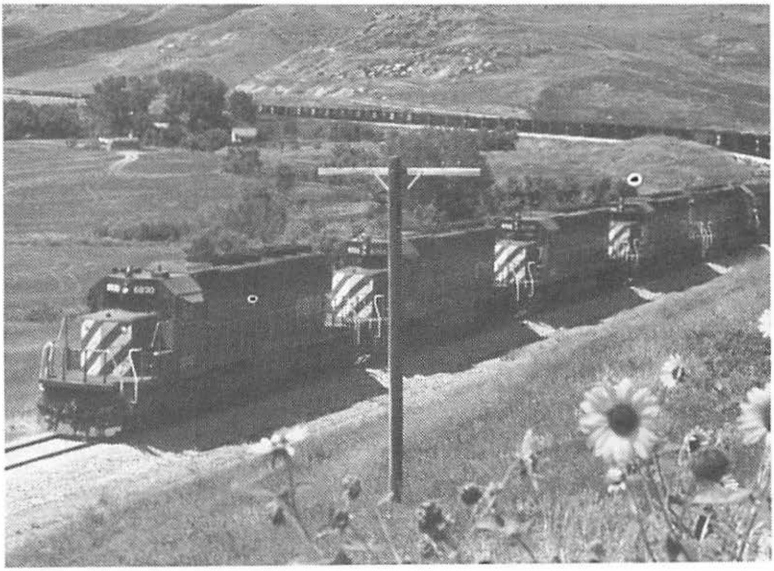
As I mentioned last year, our increase in advertising fees might be followed by an increase in membership fees. Well, this has now become so. An audit showed that our cost per member exceeded the membership fee, so for the year 1979, which starts this month and runs through September 30, 1979, railroad membership fee will be $10 and associate membership fee $15.

To the railroad membership chairmen, our thanks for their fine cooperation, without which it would not be possible for us to operate.

Special thanks to Jim Butler of Conrail for an excellent membership drive on his railroad.

Are there any questions? If not, thank you.

Seated left to right: 2nd Vice President Jim Long; Past President Ky Pruchnicki; President Eldon Dent; 1st Vice President Tom Harley; 4th Vice President Nelson Buskey. Standing, left to right: 6th Vice President Dick Holmes; Secretary-Treasurer Joe Koerner; 5th Vice President Frank Bruner; 3rd Vice President Bob Clevenger; next is Charley Smith who leaves LMOA and Conrail to join Klauder Associates; 7th Vice President Darrell Walker.



MONDAY AFTERNOON SESSION
October 2, 1978

REPORT OF THE COMMITTEE ON DIESEL MECHANICAL MAINTENANCE

M. GOGOL, Chairman
Committee on Diesel Mechanical Maintenance
Chief Quality Control Officer
Southern Pacific Trans. Co.
San Francisco, CA

N. A. BUSKEY
4th VICE PRESIDENT
Supt. Locomotive Dept. - Oper.
Chessie System
Huntington, WV

MR. BUSKEY: Gentlemen, this concludes our business meeting.

Will the members of the Diesel Mechanical Maintenance Committee please come forward. The Chairman is Mike Gogol, Chief Quality Control Officer, Southern Pacific, San Francisco.

[Mr. Buskey introduced Mr. Gogol. Mr. Gogol then introduced the members of his Committee. The report was summarized by Mr. Gogol, Mr. F. I. Burchett and Mr. R. T. Thetford.]

MR. GOGOL: Gentlemen, that concludes this Committee's report. Are there any questions?

MR. JACK WHEELIHAN [Service Department, EMD, LaGrange, Illinois]: On the turbocharger presentation I would like to bring out one point. A suggestion I found in my experience as district engineer in the field is that you should have the turbo screen inspected first before pulling the turbocharger. I have seen many customers pull the turbocharger when the unit came into the shop with a report of black smoke and other problems, and it was later found that the screen was plugged with water treatment, and you had shot about 8 hours of labor. You should inspect the turbo screen before you do anything in the turbo.

MR. R. T. THETFORD [Superintendent Motive Power, Illinois Central Gulf Railroad, Chicago, Illinois]: I neglected to say that most railroads in the survey were following the EMD "Troubleshooting Guide."

MR. GOGOL: Most railroads were following EMD's recommendations in their turbo checklist. For the railroads that are not aware of it, both locomotive builders are very cooperative in offering turbocharger checklists for the manual, and they will even make arrangements to have one of their men come out into the field and hold classes on this subject, which is very worthwhile.

MR. LEEDY: On the turbocharger presentation, EMD as I understand it, the primary cause of failure is overspeed and low heat. I am wondering if EMD has thought about a practical way to set this overspeed condition and shut the engine down. If I understood the report, GE has a speed-sensing probe; is that right?

MR. GOGOL: The one on the GE is used for another purpose, Bob.

MR. LEEDY: Has the Committee any information on a speed sensing device for an EMD turbo?

MR. GOGOL: This subject has come up a number of times in the past. People have been interested in developing such a probe to sense a turbo that would be getting on the verge. All the information the Committee has been able to develop to date is that there is nothing available or on the market that is fast enough to shut the engine down before the damage occurs. It may be a worthwhile device to have, but right now it is not available.

Would one of the builders like to comment?

MR. L. F. TURNEY [Manager Technical Section, EMD, LaGrange, Illinois]: EMD has been testing a device which will sense both overspeed and rapid rate of speed change. Testing at this time has shown no great promise.

MR. DAVID I. SMITH [Senior Factory Service Engineer, General Electric Company, Erie, Pennsylvania]: The speed probe we have in our check system has two functions. One is used if the turbo is running too slowly during engine acceleration and load application. It also functions as a speed limiting circuit in the event some fault may put the turbo into the overspeed zone. It will prevent the turbo from entering the overspeed zone.

MR. GOGOL: I have a question from the podium. What has been the Committee's experience with Arrowsmith and Elliott turbos? Arrowsmith would be EMD turbos rebuilt by Arrowsmith, and Elliott would be the GE turbos.

Bob, would you like to make some comments. I think you have had some firsthand experience with Arrowsmith. I see our Arrowsmith friends in the audience, and maybe between the two of you you can came up with an answer.

MR. THETFORD: We are running right now about 70-75% of our turbocharged power with Arrowsmith turbochargers. We have been with them since 1970 and we have had some very good years with them. They have had some problems in the last couple of years, and I think they are working out their problems, and it is going to take a little time to tell. Where they are right now, we really can't tell you. We have been satisfied for the most part with their service and with the cost savings they have given us.

MR. BURCHETT: On the Elliott turbo referred to as used on the GE locomotive, you are all familiar with the fact that Elliott originally built the turbo for the GE locomotive. They continue to build a turbo for GE. GE has gone in two lines. They continue to use the Elliott turbo on their locomotives. They are building a turbo of their own. It might be beneficial to the railroads to further expand on this as we have with Arrowsmith. Get a better mousetrap or take the same mousetrap and get a better turbo out of it.

MR. LEEDY: Dave said they have a speed sensor to check the overspeed zone. Is that going to protect it?

MR. GOGOL: It is not 100% effective, Bob. It requires that you do proper maintenance.

MR. LEEDY: I understand that, but apparently GE is satisfied with their system, and evidently it is working.

MR. GOGOL: As I said, the Committee survey indicated that with the number or percentage of turbo failures on GE units, if you are not maintaining the locomotives at a reasonable degree of preventive maintenance you are going to experience a high percentage of GE turbos failing due to overheat and overspeed and foreign object damage. It is a very expensive turbo to repair. GE rebuilds most of their turbos at one location now, and their biggest causes of failures are overheat, overspeed, and foreign object damage.

MR. LEEDY: Then I guess I have an argument with EMD, because if they have something that will recognize an overspeed zone, why can't EMD come up with a speed sensing system of some kind?

MR. GOGOL: I will ask EMD to comment on that if they wish.

MR. TURNEY: As I mentioned earlier, EMD is researching overheat-overspeed protection devices. EMD tests thus far have shown no promise. Testing GE is doing in this area is unrelated to the EMD approach due to the difference in engines.

MR. GOGOL: I would like to back up for a moment. I see Wayne Ewing, from Arrowsmith, in the audience. I wonder if he would like to comment on his Arrowsmith turbos.

MR. WAYNE EWING [Arrowsmith Tool & Mfg. Corp., Los Angeles, California]: Thank you, Mr. Gogol. I thank the Committee and you, Mr. Thetford, for those kind words. I believe you do have about 75% of our turbos in your fleet remanufactured, repaired or whatever.

I would like to explain our reasons for being in this business. When Mr. Dave Neuhart, of the Union Pacific, commissioned us about a dozen years ago to get into the turbocharger repair business, he said he wasn't satisfied with the quality that he was getting from the builder and he certainly wasn't satisfied with the price, and also because we were an aerospace-oriented company with a great knowledge of the behavior of exotic materials such as Inconel stainless and titanium, maybe there could be some innovations. Following what Mr. Dent mentioned in his opening remarks about innovation, this is where we come in.

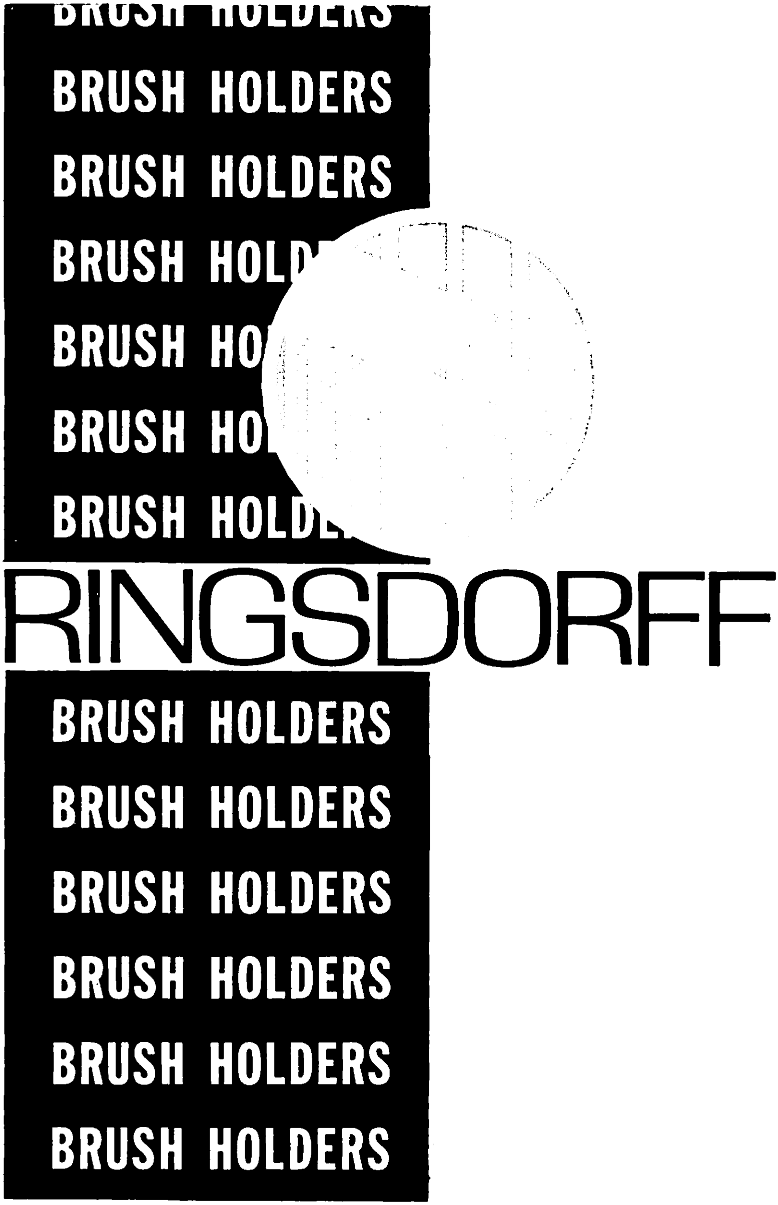
Some of the problems we have had we have been dedicated to. It is our charter that we continue to explore better ways of preserving turbo life, and we have done that. Although we didn't get the credit for it, we were the first to chrome plate clutch ramps. Whether it is a good idea or not, there is an argument in either direction. We were the first, I believe, to put a felt metal material in the shroud around the outside of the buckets to save some cost on the turbo if and when the buckets do stretch.

Knowing and agreeing that overheat and overspeed are inherent problems and also, as Mr. Turney pointed out, they haven't licked them and probably won't for some time because the anticipation of overheat and overspeed is a very short-lived thing. You are going to have it, and shutting off the fuel doesn't do any good, for there is too much combustion in there and it doesn't need a spark to ignite it. So, therefore, we have the condition.

Mainly we have to just put a band-aid on the problem and try to do the best we can. We changed from Greek Ascoloy material in the buckets to Inconel, which is very costly. It costs about twice as much as the stainless or Greek Ascoloy bucket. Inconel doesn't mind 1900 degrees, and this is what the turbo sees at times in the case of overheat and overspin.

We have tried bearings with ramps and without ramps, oil wedges, if you will, even silver material on bearing spots, Inconel buckets, felt metal outside of the buckets in the shroud to preserve the hot wheel if it does get away, and I have to say in defense of our company that we are continuing to experiment.

We have those ups and downs that the Illinois Central Gulf Railroad was talking about. We think we have something. We put it in a few turbos and unfortunately it is down instead of up. As long as we are in this business and you people will bear with us, improve-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ments will be made. EMD has 95% of it now, and we have the other 5%. We will keep experimenting and trying to improve the product and the volume. I know that we have made progress because some of our methods have been adopted by EMD, and they must like them or they wouldn't do it.

Thank you, Mr. Gogol and your Committee, for your time.

MR. BRUCE GRUBER [Triangle Engine Rebuilders, Inc., Chicago, Illinois]: I wonder if anybody on the Committee has noticed any improvement in service life on the gear-driven oil pump on the air compressor versus the conventional oil pump.

MR. GOGOL: Service life? I don't have any figures. The only data I have seen was the constant oil pressure of the gear-driven versus the fluctuating oil pressure with the strap type.

MR. LEEDY: Mike, on the viscous damper, is there something beyond the viscous damper that is in final design?

MR. GOGOL: The builder has had a gear type damper out on trial. In fact, the population of the gear type damper has been increasing recently. Lou might want to comment on how many or what percentage are in service.

MR. TURNEY: I have no figures handy on how many are in service, but they are performing very satisfactorily. It is too early to compare service life to a viscous damper, which is nine years. The gear damper has only been on test four years. Some minor changes were made during early testing, and the dampers have been operating satisfactorily as indicated by periodic project inspections.

MR. LEEDY: Do you anticipate that the gear type will replace the viscous and spring pack on all model engines?

MR. TURNEY: Early in 1979 EMD plans to adopt the gear damper as standard on all model 645 turbocharged engines. I am not aware of any EMD plans to replace spring pack type dampers with gear type dampers.

MR. T. F. KELLY [Superintendent Locomotive Shops, Chicago, Rock Island & Pacific Railroad, Silvis, Illinois]: Mike, on this air compressor business, I don't know if we are looking at air compressor failures. Perhaps we ought to look around the air compressor and forget about it for awhile. We have had gear pump compressors fail, too. There is something that for some strange reason evacuates the oil from the compressor. There is no good reason why, with a high base compressor, we should ever run out of oil. If it is serviced on the service track it should run for a year without running out of oil. There is something that is taking the oil out of it. Most of our failures are on compressors in the wind tunnel. I have a strange feeling that the fan is evacuating the oil from the compressor through a vacuum.

MR. GOGOL: Are you talking about GE application?

MR. T. F. KELLY: Yes.

MR. GOGOL: I wonder if the GE people might comment on that. I thought I saw the GE air compressor expert in the audience. I don't see him right now. I agree with you, Mr. Kelly, the cooling fan on the GE does have quite a suction.

MR. T. F. KELLY: For years we operated from a low base compressor and didn't put oil in it for from 3 to 6 months. Now we have an air compressor with many more gallons capacity and we can't keep it running because of lack of oil. The alignment on the front end is not the best in the world, anyway. It whips out the seal. We are blaming it on the compressor when maybe there is something else we should be looking at.

MR. GOGOL: Probably, but the Committee has not been able to develop any data that would point in that direction. We do know that one of the big causes of air compressor failure is lack of lubrication.

MR. FINDLING: My question is relative to battery life during the winter season. Does the Committee have any experience with batteries failing that have 19 plates versus those with 25 plates? I would like an opinion on whether they think a 25-plate battery can be substituted for an 18-plate battery and still give the same results.

MR. GOGOL: I don't have the information here, Mr. Findling. That is usually handled by the electrical men. Maybe someone on the Committee has some information.

MR. HARLEY: You might bring that up in the What's Your Problem session tomorrow.

MR. GOGOL: Yes, we will defer that to the What's Your Problem session, because we will have the electrical representatives there. We did find that certain railroads under extremely cold conditions did experience freezing batteries if they didn't keep the charge in the battery up to a certain level.

MR. HARLEY: Mike, concerning the locomotives we bought from EMD in recent years, in the turbocharged model, we have opted for an extra cost, inspection port and parts catcher added to the exhaust manifold right in the immediate area ahead of the screen.

I wonder if any members of the Committee have any comments about that particular modification. To the best of my knowledge it is still an optional modification and not a standard part of the locomotive, although some changes could have occurred more recently that I am not aware of.

MR. GOGOL: That is available in one of two ways, Tom. You can get it with the inspection hole itself, which gives you a quicker inspection of the condition of the screen itself, or you can get the latest configuration available from

EMD as a kit or replacement. It has the debris or parts catcher plus the inspection hole.

MR. HARLEY: Do you recommend retrofitting it on existing locomotives?

MR. GOGOL: I myself would recommend it if you are going through any type of rebuild or assembly change, because it does save you time on inspection of the screen and one of the steps in your troubleshooting because of black smoke or turbo failures. If you troubleshoot step by step as recommended in the Checklist, you can usually find out the cause of the turbo failure.

Again I will emphasize that the service life you experience with turbos has a direct relation to the maintenance practices.

MR. THETFORD: Mr. Harley, on that screen, we have had some recent failures on our railroad. We are looking very hard at this turbo screen, where the EMD screen is put together with a sleeve and welded on the end.

Due to the different expansion of the metals we are experiencing foreign material bypassing around the outer rim of the screen and getting in between the screen and housing. It had not been picked up by our shop forces, and we are finding screens that have been reinstalled with this foreign material in there. It then rolls around until it gets small enough that it comes through the slot, and you then have turbine damage.

MR. GOGOL: One more thing I might mention is that when you have the screen out you should clean it and check it for cracks.

MR. LEEDY: On the turbocharger, you recommended a scheduled changeout. Are you recommending changing the screen on a periodic basis to overcome this problem Tom just alluded to on the separation of the metal?

MR. GOGOL: If you are changing all assemblies on the locomotive, that is the time to look at the screen and consider replacing the present screen with the latest one that has this inspection hole plus the parts catcher.

MR. LEEDY: In other words, if the screen is a problem you are recommending that we set up a program to change it regardless of whether it has a failure?

MR. GOGOL: It is either plugged or can develop cracks, and it may form foreign objects that can damage the turbine. We don't see too much of this now, as compared to what the problem was in the initial use of the screen by EMD.

MR. LEEDY: I have another question. Believe it or not, the Farmer's Almanac says this is going to be a winter as bad as last year, and maybe a little worse. How many people are converting over to air-cooled compressors? I know a couple of railroads are starting in that direction as a result of the weather last winter. This winter is going to be a real

cold one. Read the Farmer's Almanac. [Laughter]

MR. GOGOL: What you are saying is that we are going to have three severe winters in a row. That will be almost unbelievable. I do understand a number of railroads are trying air-cooled compressors because of the freezing condition on compressors and the damage that results. I don't know whether they have changed their standard or they just have a number of them on trial.

MR. BURCHETT: We ran some unofficial tests after the cold weather a year ago last winter, and we couldn't get the parts to repair the compressors with, so we ran some water-cooled compressors that had water jackets broken. We disconnected the water lines. We were told this would be detrimental to our air compressors. We had an alternative detrimental to use if we didn't run the power. We chose to run the power.

The unofficial test was that during the summer operation we do operate in some hot climates, and our shop maintenance is not the best, and these air compressors went through the summer without having their water jackets changed. So, last winter when we had cold weather we did start immediately to disconnect the water lines from our air compressors on GE locomotives only, and we were very successful in operating without air compressor freeze-ups.

MR. LEEDY: Did you hook them back up this summer?

MR. BURCHETT: Our people assure me that every one of them is hooked up. They assured me the year before that they would hook them up, and we ran without them being hooked up. However, when we went into the fall weather we made a personal check and found their assurances weren't too good. [Laughter]

Mike touched on something that I might bring out. We talked about turbochargers and maintenance being directly related to turbocharger failures. I do agree with Mike, but there is another thing beyond that.

If you have a locomotive that you change the turbo on, and repair whatever caused the turbo to fail, and put a rebuilt turbo on there, I don't care who you get it from, just because you have a rebuilt turbo doesn't mean your problem is now in the engine. You may still have some turbo problems, and it would behoove all of us to keep after these repairs, getting remanufacturing people of turbos to do some type of test program before the turbos come back to us.

We have had some really hazardous experience recently with some turbos, where we did everything to the engine except turn it upside down, and still there was nothing wrong with the engine but the turbo did not perform as it should. Don't always say the turbo is perfect because it was rebuilt by one of your approved rebuilders.

MR. GOGOL: That is true, Fred. That is one of the components that is rebuilt, and to my knowledge very few people do any break-in or testing after a rebuild. They leave it up to the work on the engine for the break-in and the testing.

MR. WHEELIHAN: EMD very extensively tests all turbos on special engines we have in our test cells, and we run them for quite some time before being shipped to the customer. Complete temperature ranges, speed ranges, and so on.

MR. GOGOL: You have a number of them? You are not rebuilding engines.

MR. WHEELIHAN: All our turbos (new and rebuilt) are put on what we call a gasifier or a special engine, with a quick bolt-up fixture on the rear for fast change-out. All turbos do receive extensive testing, both at our LaGrange plant and our Commerce, California remanufacturing branch, which are the only two locations we build turbos.

MR. D. I. SMITH: I would like to return briefly to Mr. Kelly's concern about the air compressor and the radiator fan. It is true, there is a slight pressure drop in the intake screens that surround the air compressor, but that same pressure is applied to the outside of the crankcase and the inside through the crankcase breather. It is less than 1000 feet above the normal elevation, and there is no tendency for the oil to leak or not leak due to this apparent change in ambient pressure. If there is something going on, Tom, we haven't found it yet.

MR. GRUBER: Tom, through the last two years of research and development at Triangle Engine we have found that until a ring is applied that will operate in both a positive and negative environment, especially in the low pressure positions, it is going to be pretty hard to achieve any kind of optimal oil control at all. The ring must have the ability to work torsionally within the bore. I don't know what effect the wind tunnel would have on that already bad condition.

MR. D. M. WALKER: I would add some comments about the GE compressor.

About three years ago we were having failures. We on the Southern, working with GE, have made several changes, the positive gear driven pump, the external oil filter and against the builder and the air compressor manufacturer's recommendation. Southern piped locomotive compressor crankcases to diesel engine crankcases of locomotives out of warranty. I would have to say that after almost three years we are satisfied with the performance we are now getting out of air compressors. Along with this we have made some changes in the intake air filter. The combination of changes has given Southern satisfactory performance.

MR. GOGOL: What was the change in the air intake?

MR. WALKER: We had several arrangements. Some would allow intake air leaks in joints before reaching the air compressor. GE recommended that we go into the traction motor duct for the air intake. There were several arrangements of intake air for compressors on Southern locomotives. However, I really don't think the intake air was a problem.

I think a lot of the problems might have been failure to keep the oil in the crankcase. The Southern, with the EMD locomotives, normally go from diesel engine overhaul to overhaul with air compressor. I believe we will be able to do this with the GE now. If we get by on the four-year interval we will be very happy with the performance.

The piping of the oil to the crankcase is not new on the Southern. We have been doing it for years. We did it with the SD24, GP-7, GP-9 and Alco locomotives and have many years' experience without problems.

MR. M. G. MARLER [Mechanical Superintendent - Shops, Union Pacific Railroad, Omaha, Nebraska]: My question concerns the main bearing on the GE locomotive. Our experience with this bearing thus far confirms the Committee's expectation of longer life.

My question is, with the resultant increase in oil pressure on the crankshaft, can we expect longer life on the connecting rod bearing?

MR. GOGOL: That is true, it does help the engine oil pressure. The only thing we have noticed and have had reports on (and I think GE will bear this out) is that you do have some hydraulic erosion or action on the overlay which is not detrimental to the bearing service life. It is hoped that with the grooveless con which they are feverishly trying to develop, we will have further benefit in oil pressure on the engine.

For those of you who are not making this modification on your older GE engines, the Committee strongly recommends that you do modify the caps next time the engine is in for main bearing changeout. It is well worth the extra cost.

MR. BUSKEY: Time has run out, so I would now like to call on Bob Leedy to summarize this report.

MR. LEEDY: Gentlemen, as usual we have had a very fine report from the Diesel Mechanical Maintenance Committee.

In listening to some of the discussion, it is obvious that EMD and GE are constantly searching for ways to improve the end product. I got hung up on the turbocharger, but any of you who have 200 locomotives that are equipped with EMD turbochargers (I guess the 25% applies to GE too) are failing a turbocharger at the rate of one a week. That is a pretty expensive thing. As the Committee has reported, there are a lot of things we can do to prevent that.

R. W. LEEDY
REGIONAL EXECUTIVE
Contract Administrator
Illinois Central Gulf Railroad
Paducah, KY

Water leaks are a very important subject. A lot of improvements have been made in this area over the years. I think the emphasis here is on torquing, proper retorquing, retightening, winterization programs which are right on top of us now and just a few days away, especially up north.

On dampers and fuel lines and gear-driven air compressor lube oil pumps, all these things are contributing to the successful high availability and economics we have in our maintenance programs. We still have a lot to do to improve the things we have talked about today.

I want to congratulate Mike and his Committee on their efforts in preparing and presenting this paper.

MR. BUSKEY: Thank you Bob, I agree that this has been a very fine Committee report.

I will now turn the meeting back to President Dent for his closing remarks.

PRESIDENT DENT: Thank you, Nelson. This Committee has done an excellent job, and the Chairman and members are to be congratulated for a very meaningful report. I feel the Committee deserves a lot of credit. I ask you to stand and give them a hand, after which we will recess until 9 a.m. in the morning.

[The audience arose and applauded.]

[The meeting recessed at 4 p.m.]

TUESDAY MORNING SESSION
October 3, 1978

REPORT OF THE COMMITTEE ON FUEL AND LUBRICANTS

J. D. SMALLING, Chairman
Committee on Fuel & Lubricants
Engineer of Tests
Southern Pacific Trans. Co.
San Francisco, CA

R. R. HOLMES
7th VICE PRESIDENT
Chief Chemist
Union Pacific Railroad Co.
Omaha, NB

The meeting reconvened at 9 a.m., Mr. E. E. Dent, President, presiding.

PRESIDENT DENT: Gentlemen, it is nine o'clock. Good morning to all of you. This session will be handled the same as the others, in that the reports will be condensed. Complete reports will appear in our Annual Proceedings. A discussion period will follow each report, and we ask that you make good use of the microphones. These technical committees anxiously await your input. Let's put them to work.

I will now ask our Vice President, R. R. Holmes, to come forward and be the officer for this session.

MR. HOLMES: Thank you very much, Eldon.

Our first presentation today is that of the Fuel and Lubricants Committee. The Chairman is John D. Smalling, Engineer of Tests, Southern Pacific Transportation Company, San Francisco, California.

Mr. Smalling then introduced the members of his committee. The report was presented by Mr. M. B.

Abernathy, Mr. B. C. Cain, Mr. R. A. Bjorndal, Mr. Dale Propp and Mr. K. D. Reed.]

MR. SMALLING: Gentlemen, that concludes the summation of the Committee's report. The floor is open for questions and general discussion. Are there any questions?

MR. HARLEY: I have a question for Mr. Abernathy or any of the other oil company representatives who might want to answer it.

Do you feel the increasing popularity of diesel automobiles particularly in the last couple of years may cause any serious problems with the diesel oil supply available to railroads?

MR. M. B. ABERNATHY [Manager Transportation Sales, Continental Oil Company, Houston, Texas]: I would have to say no, it does not pose a serious problem. In fact, I was at a meeting with people from Detroit just last week and they predicted that the maximum number of automobiles propelled by diesels would probably not exceed 5% within the next ten years. So, we are not looking for any great change in the number of diesel powered automobiles.

Again, the total growth and use of diesel fuel is predicted to be rather steady, between 2-3% annually in the next ten years, and we expect that growth of gasoline consumption to peak out about 1981 and then actually tail off a little bit.

MR. LEEDY: In Mr. Reed's presentation I was confused with all the numbers on car journal oil. What is the status of the new AAR journal box oil, and is it recommended for use in locomotive traction motor support bearings and general roller bearings? Does it have a number yet?

MR. C. LENZINI [Engineer of Tests, Missouri Pacific Railroad Company, St. Louis, Missouri]: Yes, there is a new specification for car journal oil with a corrosion inhibitor. It passed letter ballot just recently without any negative votes, and the specification number will be M-963. It will be made standard on March 1, 1979.

Besides the corrosion inhibitor this oil will have some of the following properties: The viscosity at 210 will be 53 to 58 SUS, which is the same as the present all-year grade. The viscosity index will be 125, and the pour point will be -35°F. This oil will be made standard, as I said, and during the interim period and until the present stocks are worked out the specifications M-906 and L-906-A will carry a status of a "limited standard." This grade of oil is much better than the present grade of car oil. Many railroads use it as a traction motor support lubricant.

MR. LEEDY: What are we talk-about in terms of cost? Will there be an increase in cost?

MR. LENZINI: Yes, there will be a cost increase. I would say possibly 25%.

MR. R. G. CLEVENGER [General Electrical Foreman, Atchison, Topeka & Santa Fe, Kansas City, Kansas]: Along with what Tom Harley said, we have been reading a lot in the paper about Gasohol. Can someone on the Committee give us some information on what is involved in producing this, and where it might lead in the major problem of operating an automobile?

MR. V. E. BROMAN [Project Engineer, Atlantic-Richfield, Harvey, Illinois]: What is Gasohol? It is a mixture of gasoline and grain or ethyl alcohol that can be used as a fuel in automobiles. It is usually 5-10% alcohol and 95-90% gasoline.

What will it cost? Alcohol costs about three times more per gallon than gasoline. A gallon of the mixture fuel costs about 10 cents more than straight gasoline.

Where will it come from? To supply the demand for alcohol used in the gasoline mixture would take all the corn crop raised in the United States. The use of this mixture does back out some gasoline, thus increasing the available petroleum supply, and this could be diverted to No. 2 fuel.

What are the problems?

1—Engine modifications are needed. Alcohol has a leaning effect lowering the A/F ratio. Oxygen in the fuel lowers the carbon-hydrogen content of the fuel. The lower A/F ratio is not compensated by the standard carburetor since it meters fuel as a typical hydrocarbon.

2—Sensitivity to water. When fuel tanks breathe, water condenses. Alcohol has a greater attraction for water and migrates to water phase.

Can alcohol be used in diesel fuels? Methanol rather than ethanol may extend diesel fuels. It burns cleanly. The Burlington Northern has made tests of diesel fuel-methanol mixtures. However, none of the test results have been made public. Methanol usage may also require engine modifications.

MR. FINDLING: When we talk about putting alcohol or methanol into the fuel, we are actually creating a mixture that will cause problems. I wonder what the state of the art is with the removal of impurities in both fuel and lube oil on board locomotives. I understand there are several companies that are into this field now, and I would like to know what the status is, whether they are really effective or not, who is using them, and how much it costs for labor and materials to apply it.

Secondly, fuel additives. AD&N has been using a fuel additive and now the Kansas City Southern is using it. Results indicate an average fuel saving of a minimum of 10% and as high as 16% in tests made on the KCS, according to the report I have. I would like to know if this is true.

I would like to know if the additive has a side effect that would be injurious to locomotive components and if there would be increased wear rates, or if it is

actually a good additive and does do what they claim it does. The product I am talking about is manufactured by Preventive Maintenance Systems, Inc.

Could you answer these questions?

MR. SMALLING: The answer to the first question, unfortunately, is one that we have not discussed on the Committee. I will enquire if anyone on the Committee might like to comment. Evidently not. This is a problem we will have to study for future reference.

Addressing the question on the additive situation, I too am interested in that particular additive you are speaking of, Mr. Findling, and if the Kansas City Southern is having success with it perhaps someone with direct experience can elaborate.

Is there anyone here from KCS who would speak on that? It seems we've struck out on both your questions, Mr. Findling.

MR. D. H. PROPP [Director, Energy Conservation, Burlington Northern Inc., St. Paul, Minnesota]: In reference to your question on fuel additives, is there someone here from KCS? I have talked to them about the test, and at the risk of getting involved in a real hassle I don't believe the results indicate fuel savings of 10-16%. From the results of tests we performed, the additives do not show that kind of success in fuel consumption savings.

VOICE: I would like to know why it is important to know the amount of lube oil consumption.

MR. LENZINI: As the paper on Strontium 88 said, it was admitted that this tracer element did not work. However, the idea of a tracer element is a good one because it will offer a quick means of determining lube oil consumption.

As to lube oil consumption, excluding leakage, we know that it indicates somewhat the condition of the engine, and especially the piston rings and cylinder liners. The best reason I can give for knowing the lube oil consumption would be to use this information in logically scheduling engine overhauls.

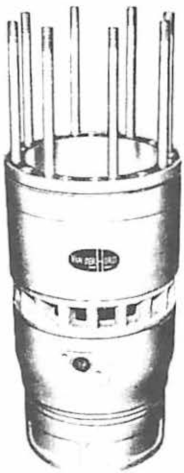
VOICE: What does the Committee consider an ideal ratio of lube oil consumption per 1000 gallons of fuel?

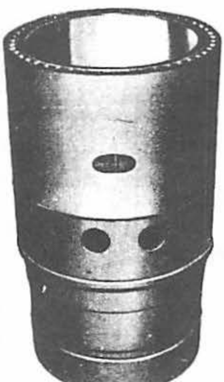
MR. SMALLING: Does anyone on the Committee know the ratio of fuel to lube oil consumption?

MR. M. KWIATKOWSKI [Technical Engineer, EMD, LaGrange, Illinois]: It is rather hard to stand up here and project how much lube to fuel ratio you can burn, but generally speaking you burn about 0.7 gallon per 1000 gallons of fuel oil in a throttle #8 position under test conditions. That is about as accurate as you can get, because as the locomotive goes on the track in various throttle positions obviously the fuel ratio and lube oil consumption ratio differ.

VOICE: Is that for a new locomotive under ideal conditions?

MR. KWIATKOWSKI: Yes.





MR. LEEDY: On the fourth generation lube oil as opposed to the third generation that was shown on the slide, the wear on the upper ring and the amount of deposits on the liner wall—for the sake of the question I am going to assume that the quality of oil filtration was the same in both cases. If that is true, then how does the fourth generation oil gobble up all those little hard pieces and keep from wearing out the rings and the bearings?

MR. R. A. BJORNDAL [Senior Staff Engineer, Chevron U.S.A., Inc., San Francisco, California]: We have a better speaker and expert on this subject than I, sitting in the audience, who came in a little late. We might have to call on him to comment to some degree.

Basically, the concept involved is that with the effectiveness of the oil in dispersing the material that could form deposits and could conceivably clog filters, the filters can do the job they are basically designed to do. These hard, small particles you refer to are actually removed from the system effectively by the filtration system provided on the locomotive.

One other factor is the length of time or service period available to you on a filter installation. Not too many years ago, a week to ten days was the type of service you typically experienced. People now are talking about 45 to 90 days of service. Better oils are required to allow the filters to be maintained in good mechanical condition during this 90-day period. Better filters are required in terms of structural integrity and resistance to damage from water contamination, and so on.

MR. LEEDY: Are you saying that the insolubles are collected by the filters more so than they are carried in suspension?

MR. BJORNDAL: Actually, less so. The material is finely dispersed, with the result that the insolubles measured in the oil will actually be higher. These are coagulated insolubles. In other words, the insolubles are removed with the aid of a coagulant. This is not material which is incipiently capable of being dropped out, but it is a measure of the material that the oil is actually carrying around safely.

The General Electric Company has established in their test work done overseas that the insolubles level may safely be allowed to rise from 4 to 5 per cent. That increased percentage of insolubles permissible, allowable through the use of the Generation 4 oil, allows a longer period of service before oil drain is required. The material is actually in suspension. If you examine it with an electron microscope, for example, you will find it extremely finely divided. Unfortunately, I don't have any photographs with me that would illustrate this phenomenon of particle dispersion.

MR. LEEDY: Then with the fourth generation oil you say the particles are smaller in size than with third generation oil?

MR. BJORNDAL: In effect, yes. Actually, agglomeration of the particles to filterable size is inhibited.

MR. LEEDY: I have another question related to this. I would like to hear some comments on the new GE lube oil filter. Is it used extensively now? What is the status of that versus the conventional paper lube oil filter?

MR. BJORNDAL: I personally can't speak to that, but perhaps Jack Hoffman can comment.

MR. J. G. HOFFMAN [Project Engineer, General Electric Corporation, Erie, Pennsylvania]: I can't give you a precise ratio of quantity of long-life type elements versus standard pleated paper elements. However, the usage is extensive with a number of major roads using them 100% in GE power.

If I might add an additional comment to Dick's remarks concerning the first question, not to change anything that Dick said but to augment it. If we remember that the particle size of the soot which is formed in the process of combustion, which is the material that makes up nearly all of the insolubles, is on the order of less than 1 micron in size, then I think we will be able to better understand that is not the material that wears out parts.

The job of the lubricant and its additive is to try to maintain that super-small size for as long as possible so that it does not grow, plugging up a filter, and, in the case of bypassing type filter systems, permit abrasive material to go around the filters and do damage. In short, the job of the oil is to keep the combustion junk super-fine, and it is not what causes wear.

MR. K. D. REED [Director, Research Laboratory, Consolidated Rail Corporation, Cleveland, Ohio]: One other aspect of the wear problem: I want to speak on theory, at least, about corrosive wear.

The higher alkaline reserve products are supposed to better control the formation of acids formed during the combustion of the fuel, and corrosive wear is reduced because of the additive left that hasn't been depleted. So, it seems to me the question of why does the higher alkaline reserve oil reduce wear is both from the standpoint of allowing the filters to do their job and controlling the corrosives that are formed. Corrosive wear may be the biggest cause of wear.

MR. LEEDY: On this filter, what is the average service life you are getting? If fourth generation lube oil is holding all these things in such a small micron size, would anyone care to predict when we can do away with filters and just put screens in there to get the chunks out? [Laughter]

MR. HOFFMAN: A reasonable estimate of typical long-life filter usage is 90 to 120 days. We permit six months. It is our determination that the structure is satisfactory for continued oil soaking up to that point in time.

Frequently other things, having nothing to do with filter plugging, dictate a filter change; so that all of those things considered, 90 to 120 days is typical.

To answer your second remark (and I am not sure whether you meant it facetiously or not), in effect, filters do their job as a screen. The point that one tries to reach is to have a filter or screen that is sized to remove those particles which will break the oil film. If we could make a filter of wire screen or other material that would have enough surface area or depth-holding capability, and keep it free of oil, sludge, and with correct hole size, we would have an effective filter.

My side of the engine builder's philosophy is, keep out the hard particles such as sand and metal chips that will break oil film and cause damage.

Oil filters in modern times have not been applied to take out sludge. In other words, they are not oil-polishing units. Since the days of the pleated paper element which permitted full-flow filtration, that has been the general philosophy. So, in reality we are using screens now that are not made out of wire.

MR. SMALLING: Gentlemen, we have run over our allotted time. In the What's Your Problem session tomorrow I am sure we will have the full Committee present and we can continue the discussion then.

Now I will ask Mr. Dale Propp to summarize the report.

D. H. PROPP
REGIONAL EXECUTIVE
Director of Energy Conservation
Burlington Northern, Inc.
St. Paul, MN

MR. PROPP: As always, this Committee has done an excellent job of answering some of our questions involved with fuels and lubrication. The number one question of course is energy, and I am sure that is in the minds of all of us. Our requirements are large. The economics of energy are high, and the environmental and social problems are going to be excessive. All of these are questions that this Committee, I hope, will attack during coming years.

Certainly the other area of testing lubrication consumption will also affect energy. This Committee represents an excellent opportunity for railroads and LMOA members to ge an idea of what is happening in the industry from the standpoint of tests performed on used oils, new generation oils, and future happenings in mechanical devices such as the locomotive wheel flange lubricator. These are all problems of great interest.

I believe we also must have a joint effort as a railroad industry, oil companies and locomotive builders, to examine and improve the lubricating system on locomotives. There are several different products that various railroads are utilizing, and this results in added costs to our industry. I hope the Committee will examine this subject more in the future.

The Committee has done an excellent job, and I wish to thank John Smalling and the entire Committee again. Now let's exhibit a bit of energy by giving them a vote of thanks. [Applause]

TUESDAY MORNING SESSION
October 3, 1978

REPORT OF THE COMMITTEE ON DIESEL MATERIAL CONTROL

J. J. GREGORY, Chairman
Committee on Diesel Material Control
Production Control Manager
Consolidated Rail Corporation
Altoona, PA

F. D. BRUNER
5th VICE PRESIDENT
Asst. CMO - Research & Develop.
Union Pacific Railroad Co.
Omaha, NB

PRESIDENT DENT: I would like to ask Frank Bruner to chair the next part of the session.

MR. BRUNER: I thought the last presentation was very good, and I am looking forward to the next report, by the Committee on Diesel Material Control.

[Mr. Bruner introduced Mr. J. J. Gregory, Chairman of the Committee. Mr. Gregory then introduced the members of his Committee. The report was summarized by Mr. Gregory, Mr. M. L. Wall, Mr. D. L. Ward, and Mr. L. S. Conte.]

MR. GREGORY: This Committee is fortunate that we have material managers for parts from Alco, GE and EMD here, so will you please direct any questions to them or to the Committee as a whole. Are there any questions?

MR. FINDLING: This was an excellent presentation. We have just gone through two winters, and each one had problems that were not like the other. We were out of connecting rod bearings in 1977, and in 1978 we had a radiator problem. The thing fluctuates back and forth. I don't see how you can say what is going to happen next.

I realize that a review of component parts that have been used in the past is interesting, but we are also using component parts from retired locomotives. I think you should keep a record of those, and maybe a closer association with the railroads relative to what parts they are scavenging from units which are going to be scrapped should be used as input so that your calculations are more accurate as to component parts used.

MR. J. J. GREGORY [Manager, Production Control, Consolidated Rail Corporation, Altoona, Pennsylvania]: The better the railroads schedule their maintenance, the better the manufacturers can supply us the material that is needed. If you will notice, GE went from "feast to famine" on materials. The railroads stopped buying, so they cut down on their inventory. Then when spring came they were deluged with requests for material that was almost impossible to supply.

Are there any railroads that practice EMD's recommendation on scrapping high horsepower radiators after 10 years, and low horsepower radiators in 15 years? That was a lively discussion. Is there anyone whose railroad does otherwise?

MR. HARLEY: I am just wondering if some of these radiators last that long in order to have that kind of policy. I know in the instance of Conrail we are attempting to buy the newly designed radiator from EMD. It costs a premium price—the type with the rolled header. The supply is difficult to get, but we are certainly attempting to get this particular radiator because from what we have seen of it it may offer us a new life expectancy in the radiator business; and as the paper pointed out, the radiator business is a very tough area.

MR. GREGORY: When we overhaul the locomotives we attempt to utilize the new type radiators.

Are there any other questions? If not, we have used up our allotted time, and now I would like to call on Darrell Walker to summarize the report.

MR. WALKER: I would like to commend this Committee for a fine report. It is evident they did a lot of work to compile the data.

I would also like to thank the many railroads that participated. Without the participation of the railroads when the surveys were sent out, reports of this nature would not be possible to compile by committees. The information serves as a tool to measure ourselves against others. I would like to encourage in the future more railroads to participate in such surveys.

PRESIDENT DENT: Thank you, gentlemen. May we give this Committee a rising vote of thanks? We will then recess until 2 p.m.

[The audience arose and applauded.]

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

TUESDAY AFTERNOON SESSION
October 3, 1978

The meeting reconvened at 2 p.m., Mr. E. E. Dent, President, presiding.

PRESIDENT DENT: Again we would like to ask that our membership stay out of the hospitality rooms while sessions are going on. Your attendance at these meetings is a prerequisite to their success.

The What's Your Problem session tomorrow morning should be very informative. It has been suggested that you turn in your questions to any of the gentlemen at the table, whether they are wearing red coats or are committee chairmen.

Will Mr. Harley please come to the podium?

MR. DENT: At this time, Tom, I would like to turn over to you the gavel for this meeting.

[Mr. E. T. Harley assumed the Presidency of the Association.]

PRESIDENT HARLEY: Thank you very much, Eldon. I know I will be calling on you as Chairman of The Board, and Joe Koerner, our reliable and able Secretary-Treasurer, as well as the Vice

Outgoing President Eldon Dent passes gavel on to newly elected LMOA President Tom Harley. Looking on are LMOA Vice Presidents Jim Long and Nelson Buskey.

Presidents, Executive Committee members, and the various committee chairmen during the coming year.

When you look at the process necessary to become President of the LMOA you wonder how anyone ever makes it. First you become a committee member; then a committee vice chairman; then you serve as a committee chairman for about three or four years. The next step is the Executive Committee, which has seven positions, each requiring a year. Then the seven Vice Presidential steps must be taken one year at a time. The net result is a process that theoretically takes nearly twenty years. In actuality it usually takes a few years less, but it is still a procedure that encompasses about one-half of your working career.

Along the way there are many pitfalls, the biggest of which is retirement. In past years, age 65 was considered the standard retirement age on the railroads. Today, age 60 is more standard on many railroads, so if you start through the chairs in the LMOA a little late you may not make it.

Tom Tennyson, our President before Eldon Dent, just made it in time; in fact, I think he retired on the airplane on his way back to California after the 1977 annual meeting.

There is also the hazard of being promoted to a position where the demands are too great to participate in LMOA activities. An example of this is Frank Fisher, who was promoted to Operating Vice

Past President Ky Pruchnicki, far right, was called upon to make several presentations. Here he is shown awarding Eldon Dent the coveted "General" desk set and life membership in LMOA. Far left is Vice President Frank Bruner and center is Vice President Bob Clevenger.

President on the former Reading Railroad. Frank was an enthusiastic supporter of the LMOA, but just couldn't devote the time after his promotion.

Other examples of pitfalls along the road include transfer to a department which is not concerned directly with locomotive maintenance, changing jobs to a position in which there is no time or travel expense available for LMOA committee work, and in addition there is always the possibility of a change in position when the individual is no longer working for a railroad even though it may still be deeply involved in railroad-connected work. So, you can see it is a long road, and a road strewn with all sorts of road blocks. But I am happy to be here as a survivor of the LMOA selection process.

Another example of survival which I would like to discuss briefly is the present state of our industry. The sad thing about this state is that there is nothing inherently wrong with railroading, per se. Just take a look around the world and see that railroading in almost all places except North America is a prime and growing form of land transport. The Soviet Union is spending $15 billion for a new trans-Siberian line, twice the expenditure of the Alaskan pipeline which was our biggest private capital project, and they have no plans for a Moscow-Vladivostok superhighway or canal not in the present Five-Year Plan, the next Five-Year Plan, or possibly ever.

C. M. Smith, former Conrail and LMOA officer, is shown receiving the "General" award from Eldon Dent. The award was in recognition of Charlie's successful years of service with LMOA prior to leaving the industry for the consulting field. LMOA Vice President Jim Long adds his approval.

The expanding Third World nations in Africa and other places are spending their meager resources on railroads as the prime form of land transport, but here our railroads particularly in the Northeast and Midwest barely exist. We are hurt because of governmental support to our competition. Internally we fail to utilize our personnel and equipment effectively for a number of reasons, some of which are not within our own control.

Finally, we are saddled with new regulations made in the name of safety or environment, many of which cannot pass the test of cost effectiveness. I can only hope that because of our "good guy" image in the energy consumption area that help is on the way.

The realities of the political process, however, will dictate that the real help will come only when you are unable to go to the local gas station and say, "Fill 'er up."

Again I thank you for the honor of the LMOA Presidency and all it means in our unique area of improving locomotive maintenance and availability. I intend to serve you faithfully during my term of office. Thanks again. [Applause]

PRESIDENT HARLEY: Now I would like to call on our Past President, Ky Pruchnicki, who has graciously agreed to do several jobs today. He will present Life Membership to Mr. Dent and to Charlie Smith, and he also will present the President's Pin to Mr. Dent plus a bound volume of the 1977 Proceedings.

Ky Pruchnicki, right, welcoming Eldon Dent to the Past Presidents Club presents him with the attractive, gold, gavel-embossed past president's pin. LMOA Vice President Dick Holmes beams his approval.

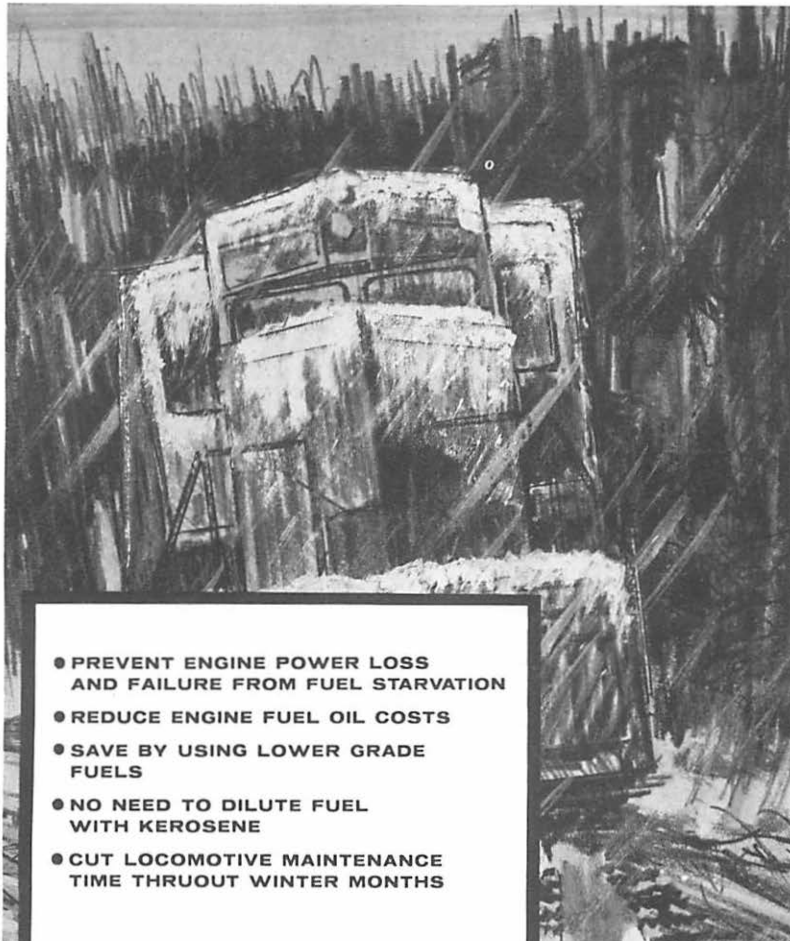
[Mr. Pruchnicki presented to Mr. Dent his Past President's pin and a copy of the 1977 Proceedings.] [Applause]

MR. DENT: Thank you, membership, for your support during my year as your President. Thank you, Mr. Koerner, for helping make it possible. Without your help the success of this meeting wouldn't be possible. I thank all of you [Applause]

MR. PRUCHNICKI: Vice President Charlie Smith is leaving the LMOA for a better position with a consultant firm. We will miss Charlie. He has done a wonderful job with this group. Charlie, may I present you with this Life membership. We wish you the best of luck in your new position. [Applause]

MR. C. M. SMITH: Thank you, Ky, and thanks to all the members of the Association who have worked with me over the years, members of the Shop Equipment Committee who supported me while I was their Chairman, and thanks also to Joe Koerner for all his help. To all the officers, past and present, may I say thank you again. I hope to be with you whenever possible in the coming years. [Applause]

Ky Pruchnicki, far right, again makes presentation to Past President Eldon Dent. This time it is a bound volume of the Association's reports and proceedings covering his term of office. Also in the picture are LMOA Vice Presidents Frank Bruner and Bob Clevenger.



TUESDAY AFTERNOON SESSION
October 3, 1978

REPORT OF THE COMMITTEE ON DIESEL ELECTRICAL MAINTENANCE

C. E. PALME, Chairman
Committee on Diesel Electrical Maintenance
Diesel Electrical Engineer
Chessie System
Huntington, WV

R. G. CLEVENGER
3rd VICE PRESIDENT
General Electrical Foreman
Atchison, Topeka & Santa Fe Ry.
Kansas City, KS

PRESIDENT HARLEY: Thank you very much, Ky.

I will now turn the meeting over to our Second Vice President, Bob Clevenger, who will serve as officer of this session. We will ask the Diesel Electrical Maintenance Committee to come forward, please.

[Mr. Clevenger introduced Mr. C. E. Palme, Committee Chairman. Mr. Palme then introduced the members of his Committee. The report was summarized by Mr. G. W. Whittaker, Mr. T. L. Westerfield, Mr. H. G. F. Stringer and Mr. Palme.]

MR. PALME: We will now open the floor discussion.

MR. CHARLES HORTON [EMD Engineering, LaGrange, Illinois]: I would like to take exception to the statement with regard to the use of phosphor-bronze alloy terminals. We looked at it and also ran some tests. Basically, what the tests brought forth was that there is virtually no difference between the tin-plated brass that we use today and the phosphor-bronze.

The primary thing people are looking at in phosphor-bronze is a spring characteristic. When we looked at the tests for both the stress relaxation and also the changes in crimp resistance we could not tell any difference between the tin-brass and phosphor-bronze. Basically, if people feel that maybe they ought to go to some kind of higher spring force, beryllium-copper is the material to investigate but it is not available right now. It is a tremendous cost increase and it would take all new tooling. So, at least based on what we know at this time, phosphor-bronze is not the answer.

MR. H. LIBAN [Electrical Engineer - Locomotive, Consolidated Rail Corporation, Philadelphia, Pennsylvania]: I don't know under what conditions you tested these things and how you arrived at your conclusions, but we did it on the locomotive about three years ago. We have changed over to phosphor-bronze and have had excellent results.

MR. CARL E. PALME [Diesel Electrical Engineer, Chessie System, Huntington, West Virginia]: Has there been a change in the old connector within the past three years?

MR. EDWARD BOLTON [AMP, Inc., Valley Forge, Pennsylvania]: The test was conducted in a 33-day heat aging process developed by Bell Labs, where the connector was put under temperature of 244°F, and at intervals of 1, 2, 4, 8, 16 and 33 days it was taken from the test and random samples were taken and tested for insertions and withdrawals. This was the comparison of the two metals.

MR. LIBAN: I repeat what I said. Field tests are more reliable.

MR. PALME: Are you saying there is no significant difference?

MR. BOLTON: Yes. We will be glad to work with you, Henry. We can come up with failures in the field.

MR. WESTERFIELD: Not being familiar with the details of the testing, I am stepping out on a limb and sawing it off behind me. My experience is that the principal problem with the brass connector is not with the temperature it is applied under, but with repeated insertions and removals, partly due to the requirement to open circuits during maintenance procedures, and that this should be the criterion that is used.

MR. BOLTON: One of the tests done was repeated cycle testing, and the fast-ons that were used were the male tapper in EMA specifications and the fast-on tap with its tolerance of .022 to .028 going upon a .032 pneumosized tap. This went into cycles up around 1000 cycles, and there again we saw no difference between the phosphor-bronze and the tin-plated brass.

MR. PALME: I have a question from Tom Harley. When we ran the EMD locomotives in this load supply system on emergency standby power, was the turbo on or off the clutch?

Most certainly it was on the clutch when we ran it, because we were pulling relatively low demand off of this locomotive in roughly 6th notch to give us 620 rpm, and most certainly the turbo was well on the clutch, I am sure.

Electro-Motive tells me we should have loaded the unit up above 80-90%. We were told by EMD we should have expected just what happened to us, because we were not loading that locomotive properly for standby power.

VOICE: If you loaded up the full #6 throttle it would not come off the gear train. It would be closer to #7.

MR. PALME: Right. We did carbon up, and EMD feels it was partly because of the light load. They warned us of possibly some gear train damage, but we apparently didn't suffer any.

PRESIDENT HARLEY: Yesterday at the meeting there was a question asked by Frank Findling that would probably more appropriately go to this Committee. It had to do with battery failures in cold weather. I realize that is not part of the Committee's topics, but these people do work with batteries and do suffer from frozen batteries. Frank, will you please rephrase your question?

MR. FINDLING: One of the things that happened to us last year was that we had engines die on line of road, and when we tried to restart them in some cases the batteries were down and we couldn't restart them. In some cases the batteries were relatively new and had been serviced properly. The batteries that failed were 19-plate batteries. The 25-plate batteries would start. I thought perhaps this Committee might have some information relative to their experience during cold weather.

We are now equipping all of our road units with 25-plate batteries, and we are downgrading our 19-plate batteries to switcher service in order to avoid this problem next winter. Does the Committee have any experience in that area?

MR. D. I. SMITH: When I want to know about batteries I talk to Bill Kelley, who used to be with Conrail. He will be present at the What's Your Problem session tomorrow, and he has agreed to speak on this subject if you want to bring it up. I see Bill is here now.

MR. W. E. KELLEY [Louis T. Klauder & Associates, Consulting Engineers, Philadelphia, Pennsylvania]: The year before last we had a very cold winter on Conrail, and at that time we had a lot of calcium batteries on our railroad. We got a report from our shop people that all calcium batteries were failing and no other batteries were failing, so we took a personal look.

There were a lot of calcium batteries that had failed, but only in proportion to the number of calcium batteries we had. We also had Surrette 29-plate batteries, Gould and KW 25-plate batteries, and Excide MC420s, which are 19-plate batteries. There was a proportionate number of frozen batteries of all makes. It wasn't a matter of how many plates the batteries had, or what the battery

construction was; it was how dead locomotives were left out in cold weather with battery switches on and batteries completely discharged.

The 25-plate batteries are rated 426 ampere hours at the 8-hour rate. The 19-plate batteries are rated 420 ampere hours, and when you drain the ampere hours out of them the gravity of the battery goes down to a level that is almost water and you will have a battery frozen in cold weather.

It is a matter of how you treat the batteries. Discharged batteries of any type will freeze in cold weather. The only thing we did see in the 25-plate batteries is the fact that the 25-plate batteries appear to have a stronger case, and we saw less complete failures of cracked monoblock trays on the 25-plate batteries.

On the newer unitized batteries, both the antimony and calcium batteries have individual cells in a high-impact case inside of the plastic outer tray. Very few of those had complete failure of the outer tray of the battery.

MR. PALME: Bill, do you think a 25-plate battery can better handle the tremendous inrush than a 19-plate, or don't you think there is any difference?

MR. W. E. KELLEY: That is one of the things we have talked about with the suppliers. I think our whole industry has to take a look at what we are getting in cranking power out of a battery. You can design a 19-, a 25- or a 29-plate battery with various amounts of plate area in contact with the electrolyte of the battery. The battery with the most plate area exposed to electrolyte will provide the most short time amperes for cranking.

Yes, the design of the battery will allow you to have more total cranking amps available. If you look at automotive starting batteries, they are definitely specified for the cranking output. I don't think any of us really know what the cranking output is for diesel starting batteries we are buying today. We buy them at an 8-hour rate, which is more what the battery will do in standby service. I don't think any of us buy a battery specifying that we are to get 2000 amps or 2500 amps for so many seconds at a specified temperature, and that this cycle can be repeated so many times.

MR. WESTERFIELD: I have found that particularly in regard to charging the batteries in cold weather, I had to do a lot of homework myself last winter. I found there are some misconceptions in regard to the settings of the voltage regulators, and there are some severe problems that we face in terms of trying to keep the batteries up in very cold weather.

In a lead acid battery, if you charge it with fixed voltage, the charging current is cut in half every 15°F. that the electrolyte temperature drops. That says that if we set our voltage regulators for proper charging current at 75°F, by the time the temperature

gets down to zero they are getting approximately ⅓d of the charging current that they got at 75°F.

We have a second problem. I am not trying to pick on EMD, but it happens to be the system I am familiar with. The voltage regulator senses the auxiliary generator output voltage. Between the auxiliary generator and the battery terminals there is a reverse current rectifier which has something in the neighborhood of 0.7 to 1 volt drop across it, and a 0.05 ohm balance resister which has a #1 volt drop across it. This adds up to at least a 2-volt difference between the auxiliary generator output voltage and the battery terminal voltage. Depending of course on the condition of the cabling between the auxiliary generator and the condition of the battery terminal, this could be even worse.

In severe cold weather, a marginal voltage regulator setting combined with the voltage drops between the auxiliary generator and the batteries will result in inadequate voltage to maintain the batteries in a fully charged condition.

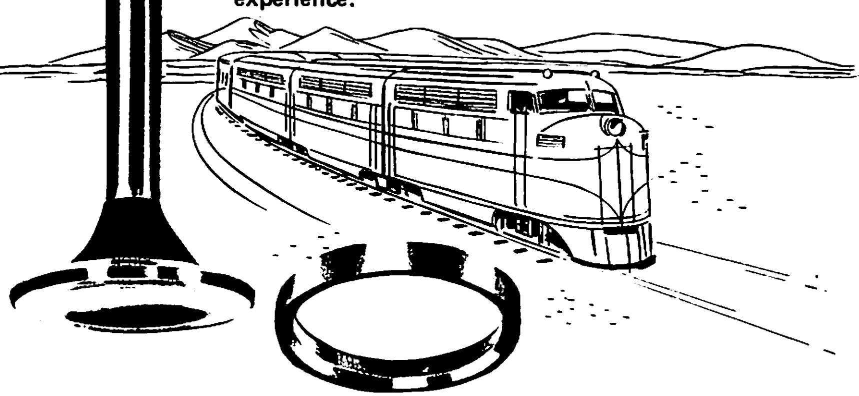
On our property we are experimenting with raising the voltage regulator setting, trying to find something that matches an average of what we need at the battery terminals. The batteries need voltage at their terminals. The rest of the system gets its voltage from the auxiliary generator, and there have to be some adjustments made.

I can also say the adjustment I make in northern Minnesota is not the same adjustment as a man makes who is operating across the Mojave desert, because he is working on the other side of the system. He is going to boil the batteries dry, and the man who has to run back and forth between Chicago and New Orleans is in deep trouble.

MR. LIBAN: We should differentiate between the style of voltage regulators we are dealing with, the static or mechanical. We had a controversy going on for several years about voltage setting with battery switch open or battery switch closed. We arrived at the conclusion that you should do what the manufacturer recommends: Set it (on static style) with the battery switch in closed position in the 8th notch at 75 volts at the battery switch; then you have the right setting.

MR. FINDLING: This goes right back to what I said earlier in the session — that we are going to have to be more innovative. We are talking about a situation here where you have a fluctuation in the voltage delivery of the voltage regulator based on climatic conditions. There should be some kind of temperature control for voltage regulators to compensate for this.

We have a situation similar to that which you described. We run all the way from Minneapolis to Houston and our locomotives don't have a home in cold territory nor do they have one in warm territory. As a result, we can't use



the blanking plates. We couldn't keep adjusting the voltage regulator.

I am sure other people have the same problem, and if the Frisco/BN thing goes through you will have the same problem. More and more problems are being faced today because climatic conditions under which we operate fluctuate so greatly.

A good item for next year's Committee could be the subject of batteries, as it is apparent we need to know more.

MR. PALME: I see Harry Quinn in the audience. He should have that design for us before next year's meeting.

MR. HARRY QUINN [Engineering, EMD, LaGrange, Illinois]: At the last LMOA meeting we talked about voltage regulators. Up until just this past year the battery people were telling us you couldn't do anything with the voltage to help the battery in winter weather. We have now changed that stand, and hopefully we will have some ready for project on the Rock Island. It is in the works.

MR. KELLEY: What is the maximum voltage setting you are going to have?

MR. QUINN: I don't know. I would guess something like the 78 volts that we have today, but I really don't know the answer, Bill.

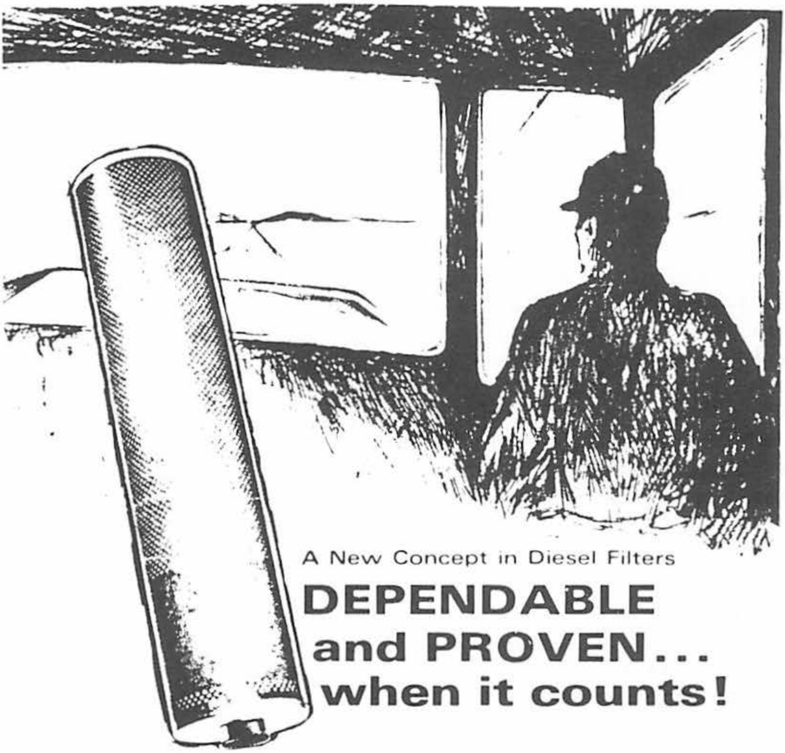
MR. FELIX STONIS [Chandeysson Electric Company, St. Louis, Missouri]: Some of the problem you will usually find is in the meters. They will vary from 2 to 3 volts. You have to have very accurate meters in the wintertime to work with.

MR. QUINN: Felix, since you were a boy, meters have changed quite a bit. I think almost all the roads are using digital type meters, high impedance meters. At one time I would have complained about a Simpson meter, but I don't think any railroads are left using those. They should have the meters available to give them the accuracy they want.

MR. WESTERFIELD: That is my answer, too. We are talking about fractions of a volt difference in the regulator setting, doubling or cutting in half differences in the charging current, and great differences in the life of the battery.

MR. G. W. WHITTAKER [Superintendent Locomotives - Electrical, Illinois Central Gulf Railroad, Chicago, Illinois]: I have one comment on meters used to set voltage regulators with. We do use SEARCH. If you use the SEARCH machine to set your voltage regulators, and are looking between the 1st and 8th throttle notches, you may find as much as an 8 to 10 volt swing. We were changing voltage regulators up like popcorn, until McGraw Edison came out and looked at the voltage regulator closely. There is apparently enough garbage on the voltage regulator output signal so the SEARCH machine cannot read it accurately.

Here again you may run into the same thing with your digital multi-



meter. As long as you are reading a sine wave or something close to it, or if the DC signal is clean, the reading you will get will be accurate. But if you get garbage on it, there is no telling what reading you will come up with. It is not a 2 or 3 times or plus 50% reading — it is a random signal, and sometimes you can come up with some screwball readings on those types of meters.

MR. QUINN: I hate to bring up the subject of AC auxiliary generators again, but those of you who have them might remember that if you look at the face plate on the voltage regulator we have a rising characteristic on the regulator and we try to take advantage of just what you are talking about.

We figure the locomotive will spend a certain amount of time in #8 throttle and more time in idle, so we left the #8 throttle voltage go up but not try to overcharge the batteries to make some sort of compromise, so we did attempt it. I don't know how successful it was. We did try to get more charging into the batteries just by the way you were using the locomotive.

MR. PALME: Speaking for Chessie, I think it is something around 200 AC auxiliary generators, and we are still holding with two failures we had two years ago. We have had none in the last couple of years. We have taken no exception to the performance of the AC auxiliary generator. We think it is great. We are ordering it on everything we buy.

Would GE like to comment on voltage regulators?

MR. D. I. SMITH: We follow the battery suppliers' recommendations on battery charging systems, and our designs are checked before we apply it to the locomotive. If they are wrong we are wrong. We started with the Exide people.

MR. H. G. F. STRINGER [Supervisor Motive Power - Electrical, Canadian Pacific, Ltd., Montreal, Quebec]: Just a comment on the AC auxiliary generators particularly on units equipped with electric cab heaters.

Harry, it is nice to see this rising characteristic in #8 throttle, but it certainly doesn't buy you anything when you spend long hours on the siding with cab heaters going. I would certainly like to see much flatter characteristics on that voltage regulator, and not count on #8 throttle operation to bring things back up to snuff again. This is going to be a particular problem on units equipped with low idle speed, as I see it.

MR. QUINN: Harold, I am sorry I missed the first part of your comments. You were talking about cab heaters. I will have to confess that we forgot Ohm's law. We repealed it or something like that. With the first design for electric cab heat we didn't put enough cable in, and we had a big voltage drop to the heaters. As far as I know, in more recent units the cab heaters are designed to give you full output with 74 volts at the terminals as described in the manual.

Charlie, do you know what the voltage at the cab heater is? 72 was what we designed it for. You should get full output. Have you checked the voltage at the cab heaters?

MR. STRINGER: Yes, Harry, we did run into a problem with low voltage, but I don't think that is quite as significant as trying to keep the batteries charged under conditions where you have both electric windows plus cab heaters for an auxiliary load of something like 13 kilowatts. With the AC auxiliary generator and long periods in idle we don't find it will keep the specific gravity of the battery up. This is more important to us, I think, than the drop in terminal voltage at the heaters.

MR. QUINN: You are not talking about units with low idle now?

MR. STRINGER: No. Just a normal idle, but with the AC auxiliary generator.

MR. QUINN: Have you got the voltage regulator set at the maximum setting?

MR. STRINGER: Yes. It is at the throttle #8 setting. It drops down, we find, to about 68 volts at idle, which isn't enough to keep the batteries charged in cold weather.

MR. QUINN: Yes, that is too low. The AC auxiliary generator has a bigger droop characteristic with speed than the DC machine, and this is one of the problems with it. You should have enough range in the regulator to get the proper setting at the idle. Forget what is on the nameplate and set it at idle then. You will get a little more sock at full speed. It will keep the crews warm in the wintertime.

MR. STRINGER: It will keep the batteries pretty warm in the summertime, too.

MR. QUINN: You are going to have to make a summer/winter setting.

MR. STRINGER: Why can't we control this voltage? There is no use telling the fellows to get a very accurate digital meter to read a voltage plus or minus 5 volts, depending on what speed you take it at. I can't see why you can't build a regulator that will hold it right where you want it.

MR. QUINN: You're hired. [Laughter]

MR. D. I. SMITH: Our regular hold is plus or minus one volt from idle speed to top speed, full load to no load, hot or cold. I don't know what the problem is. Somehow we worked around it.

MR. W. E. KELLEY: I think we are all looking at another problem. Batteries have drained down quite frequently when locomotives are sitting on the wayside dead with a lot of electrical drain on them that is unnecessary. You can write all the regulations and rules and still not get people to go in and shut down loads which should be shut down. Until you get a low voltage cutout on the locomotive you are going to get batteries that are drained down and frozen in the wintertime.

MR. H. W. PELZER, JR. [Halogen Insulator & Seal Corporation, Elk Grove, Illinois]: At the 1977 convention, during the What's Your Problem session there was discussion on a teflon insulator band around the traction motor. Was there any discussion in your Electrical Committee on this, as far as evaluating the butt joint, endless band versus the old epoxy method?

MR. PALME: Nothing that I know of. I think that is a fine subject to add to our list. We appreciate it. This concludes our presentation and we will now turn the meeting back to Vice President Bob Clevenger.

MR. CLEVENGER: Thank you, Carl. From the number of questions we have had on the floor, and since most of them were about batteries, Carl and his Committee must have covered their problems and their subjects pretty well.

They have pointed out small electrical failures to you, how traction motor maintenance is so important because it gets into our pocket where it really counts, and because of the amount of numerical statistics that are involved in this year's paper I would strongly suggest that all of you take your Proceedings book home and read this paper thoroughly. The figures and the computations that back their statements in the report are all in this book, and it should be read thoroughly.

I think if you walk into any maintenance officer's office on any railroad in the country that follows the LMOA, you will find that they not only keep the current LMOA book available but they keep a regular library of LMOA Proceedings books for use when they have maintenance problems. It behooves all of you to use this book when you leave the meeting and return home.

Carl did a fine job in presenting his paper today, and we are looking forward to an even better paper next year.

PRESIDENT HARLEY: I have a special notice concerning all general Executive Committee and Board of Directors members. This year we will meet on Wednesday afternoon following the President's Luncheon. You will be advised of the room number. Joe says it will be in the Columbia Room. This means that we will have to get to that room directly after the luncheon. Some committee chairmen will be able to get their work done Wednesday afternoon and will be able to leave and won't have to spend another night here. Obviously we won't be able to finish everything Wednesday afternoon, and some of the work will run over into Thursday morning.

The meeting tomorrow will begin at 8:30 a.m., so be prepared to be here half an hour earlier tomorrow morning. We do have pressure on these meeting rooms both this afternoon and tomorrow noon. We will have to clear this room immediately so the hotel can set up for the banquet.

Now I would like to call for a rising vote of thanks to this Committee.

WEDNESDAY MORNING SESSION
October 4, 1978

REPORT OF THE COMMITTEE ON SHOP EQUIPMENT

E. R. HAFLING, Chairman
Committee on Shop Equipment
Asst. Mechanical Engineer
Santa Fe Railway
Topeka, KS

J. H. LONG
2nd VICE PRESIDENT
Manager Locomotive Dept.
Chessie System
Huntington, WV

The meeting reconvened at 8:40 a.m., Mr. E. T. Harley, President, presiding.

PRESIDENT HARLEY: I would like to call the meeting to order. The session chairman this morning will be our First Vice President, Jim Long.

MR. J. H. LONG [Manager Locomotive Department, Chessie System, Cincinnati, Ohio]: I would like to ask the members of the Shop Equipment Committee to come to the platform.

[Mr. Long introduced Mr. E. R. Hafling, Chairman of the Shop Equipment Committee. Mr. Hafling then introduced the members of his Committee. The report was summarized by Mr. R. E. Clawson, Mr. G. B. Sweeney, Mr. J. M. Flores, Mr. T. E. Whitten, Mr. J. E. Abramson, Mr. T. F. Kelly, Mr. P. F. Hoerath, Mr. M. G. Marler and Mr. Hafling.]

MR. HAFLING: This concludes our report, and we are now open for any discussion or questions.

MR. FINDLING: I would like to address a question to Mr. Whitten relative to the infrared ray drying of locomotive paint.

Do you consider drying the entire locomotive at the same time, rather than doing segmented drying? Secondly, could you give us some idea of what the cost is of the crane type of equipment for moving the drying panels in close to the locomotive?

MR. T. E. WHITTEN [Manager, Production Planning, Illinois Central Gulf Railroad, Paducah, Kentucky]: Prior to going to segmenting drying we looked at putting a complete oven at the end of the existing paint facility. It would cost in excess of $400,000 to $500,000 to do this.

The way the equipment is utilized in our paint facility, we thought the segmenting drying worked out well because we could move the drying banks immediately behind the paint booth as they were painted. OSHA required they be 15 feet away, and we had no problem there. We would start the drying banks after we had the paint booth past the first 15 feet, so it was really continuous.

The major expense we found in putting this installation into our existing building was that we had to update the superstructure of the building so it could handle the weight of the hanging equipment. The cost of the paint drying equipment itself, the infrared banks, and so on, was relatively small. I would say the hanging equipment, cranes, and so on, plus the drying banks, ran less than $25,000 but we had to augment the superstructure and also augment our electrical requirements to handle this infrared equipment. That ran us between $50,000 and $60,000 plus updating the structure of the building.

MR. K. H. SMITH [Chief, Motive Power and Purchasing Agent, Belt Railway Company of Chicago, Chicago, Illinois] Mr. Clawson, concerning fueling, occasionally in the wintertime particularly on units coming off the road we experienced fuel tank vent pipes plugged with ice. It is very easy to pressurize a fuel tank with our type of equipment, which is non-automatic shutoff. Will this new automatic equipment prevent pressurizing of the fuel tank?

MR. R. E. CLAWSON [General Foreman-Locomotive Missouri Pacific Railroad, North Little Rock, Arkansas]: The shutoff in this Houston system is a glass read switch that is in the top of the tank. The circuit is broken when the fuel gets to that level. The tank would have to be vented as the fuel goes in. I don't know what would happen to the pressure.

MR. K. H. SMITH: As the pressure builds up?

MR. CLAWSON: That's right.

MR. K. H. SMITH: After the pressure builds up, will it sense it before the operator would normally sense it?

MR. CLAWSON: No. It is a level indicator. It will not sense pressure.

MR. K. H. SMITH: We have experienced difficulties maintaining a tight seal between different manufacturers, fitting on the fuel tank and the nozzle fitting. You can generally get a good tight seal, but when you are fueling many different units we have had the experience of finding it difficult to maintain a tight seal even when the equipment is in good condition.

MR. CLAWSON: Another thing about the Houston system is that this solenoid valve shuts the fuel off and takes line pressure off of that connection. When the circuit is broken and the fuel stops, it stops at the solenoid valve and does not put it on the connection.

MR. K. H. SMITH: I am talking about leaking at the connection.

MR. CLAWSON: It is still going to have to be maintained. According to the user and the manufacturer, it would not take as much maintenance because that line pressure does not come on that connection, which will cause a problem.

MR. K. H. SMITH: That is where we are up against it. We see all manufacurers.

MR. CLAWSON: It would be nice if they were all alike.

MR. WHITTEN: I might comment in that regard. As long as these manufacturers don't get together and try to make their fittings fit universally, it is never going to happen. For example, at our ICG shop at Paducah we were working some Amtrak units and they had three separate connections going to the fuel tip for each type of manufacturer, so they could make sure they wouldn't have leakage. In other words, each manufacturer's type of connection was right there so they could get to it.

MR. K. H. SMITH: I am sure in this industry, particularly on many roads where they are seeing foreign units, they also incur this same problem.

MR. WHITTEN: Yes, they do, and they work like filling up your car. They stick the nozzle in and let it go as best they can.

MR. K. H. SMITH: We have had to pull the insides out of them so we could get a tight fit.

MR. WHITTEN: Maybe these people who are producing this fueling equipment should get together and try to work out something universal. That is probably out of the question because they are in competition with each other.

MR. K. H. SMITH: This is the first step toward getting full usage of the fuel.

MR. HAFLING: I might add that a few years ago we had fueling systems in our report, and we put it up to the AAR to see if they could ever come up with one standard. We still have three types of connections. Nothing ever came of it.

MR. HOLMES: Elmer, on the portant subject you presented on axle grinding, how many times can an axle be reground, and what is the condemning factor?

I have another question in regard to the two methods that were presented. In the experience of

your Committee have the two methods been found to be equally efficient, that is, the electrochemical and the mechanical method?

MR. T. F. KELLY: The number of times a gear can be reprofiled, of course, we must take into consideration how much wear we are going to permit on it before we do something about it. I think EMD has established a limit of .100, and beyond wear of .100 the gear can no longer meet the criteria of tooth width at the top. That is the real thing that condemns a gear, that is, the strength of the gear, and of course spalling and tooth breakage. You need not be concerned with the hardness of the tooth as it runs about 48 to 50 Brinell on the Rockwell C scale almost to the center of the tooth. You can reprofile until such time as the tooth width reaches the condemning limit.

I personally have no experience with both methods of grinding, abrasive grinding or electrochemical grinding. The economics, of course, in the electrochemical grinding is the fact that the gear does not have to be pressed from the axle, and it is much quicker in time consumed to reprofile a gear. I believe your railroad has considerable experience along that line. I don't know if my figures are correct or not, but I think it is in the neighborhood of maybe an hour or an hour and a half to reprofile a 62-tooth gear versus maybe six or eight hours on the abrasive grinding machine.

We have another member of the Committee here from the Union Pacific who has wide experience with that, and I would like to ask him to give us some information on that subject. Mr. Marler, will you comment?

MR. M. G. MARLER [Mechanical Superintendent - Shops, Union Pacific Railroad, Omaha, Nebraska]: The gear grinding at this time is capable of grinding three gears in an 8-hour shift. I have some early observations that it takes anywhere from 147 to 148 minutes per gear. As for experience between the electro-ground gear and the mechanically ground gear, we have had an outside concern mechanically grinding gears for us for some time, and we have had good success with them.

We have been grinding our own with the Arrowsmith machine for a little over a year, and have between 400 and 500 gears in service, but they don't really have a lot of service in a year's time. We were well satisfied with the ones we removed and looked at.

MR. JAMES MANLEY [TRW Replacement Division, Montebello, California]: We have experience with the abrasive grinding methods. As to the time consumed, we can't tell you too much about the ECG, but on the abrasive method it takes us two or three hours of actual machine time to do one gear.

MR. J. H. LEHMAN [Assistant-Engineer Shop Machinery, Illinois Central Gulf Railroad, Chicago, Il-

linois]: On air compressors that are rotary screw machines, we have to keep a certain amount of load on those machines to keep them from rumbling. With this gear reprofiling, when we increase the backlash in the gears are we stressing the gears? I know we are not stressing them in motoring. Are we stressing them if the units are being coasted or towed? Are we getting more rumbling of the armature against the bull gear?

MR. T. F. KELLY: All of the tests that have been conducted to date, and all of the information we have available, state that gear backlash has no significance whatever as long as you maintain the involute profile. Once the gears come in mesh and the conjugate action is proper, if there is no violation of it, then the teeth are always in constant mesh. When they come together in mesh they then roll and slide apart and the next tooth is in contact before the tooth behind it ever leaves. If you don't maintain a proper involute profile you get hammering and more wear; the more pounding, the more destruction you get on the gear train life and the traction motor.

MR. HAFLING: I am informed we are out of time, so I will turn the meeting back to Mr. Long.

MR. LONG: I would like to congratulate this Committee on a very well prepared paper and a thorough job on up-to-date shop equipment.

In summarizing the paper on the subject of automatic fueling, last year I talked to one of the companies that manufactured this equipment, and I asked: How come the concern that produces your equipment produces nozzles for the automotive industry that they can drop in the tank of any manufacturer's automobile and it doesn't have a lot of connections and parts to hook up? I am happy to report that this year they have a modification. There is no longer a tail hose to connect. So, I do believe our suppliers are trying to help us if we tell them what we want and need. Another feature: No more gasket connections to leak or cause spillage.

After the recent escapade of the clerical strike, I am sure all of us have had a chance to get around ready tracks and operations, and we have found out that this equipment is not as light as it looks. You start handling it for 12 hours and you find out this equipment is pretty heavy. So, I would now like to see the suppliers come up with a lightweight hose for this type of operation.

The subject of fasteners was most timely and of interest to maintenance officers.

On the re-railing equipment, the Hoesch equipment: Two years ago in Europe I had occasion to witness this equipment in operation on the German Federal Railroad at Hamburg, and they did everything but turn that equipment upside down. It was a terrific job.

Mobile crane operation is one thing I personally look at as the tool of future railroading to expeddite railroad locomotives and cars being re-railed.

It has been a pleasure to see the nice presentation on painting and drying. There is nothing that warms an officer's heart like a clean locomotive. It is the best and cheapest advertising we can offer.

Traction motor and ring gear regrinding and profiling is of interest to all of us, and the industry as a whole, if you do the work in your own shop or have this service performed on a repair and return basis.

Following up on traction motor cleaning and many other items on tool and shop production was again very timely.

This Committee is to be congratulated on a paper well prepared, properly presented, and dedicated to the Association and the industry as a whole. I would ask that you give them a rising vote of thanks.

[The audience arose and applauded.]

WEDNESDAY MORNING SESSION
October 4, 1978

WHAT'S YOUR PROBLEM PANEL

B. A. CUMBEA, Chairman
What's Your Problem Panel
Manager Locomotive Data
Systems & Procedures
Chessie System
Huntington, WV

D. M. WALKER
7th VICE PRESIDENT
Diesel Superintendent
Southern Railway
Atlanta, GA

MR. LONG: Now will the What's Your Problem Committee please come forward. Seventh Vice President Darrell Walker will please come up and serve as officer of this session.

MR. WALKER: This part of the program is devoted to you and your problems. This is the time when you can ask these experts and committee chairmen questions. Hopefully they have representatives of their committees sitting in the audience to help answer any questions you might have.

Bud Cumbea is chairman of this Committee. Bud doesn't need a lot of introduction. He has worked up the hard way, serving as committee chairman and now is one of our Regional Executives. I will now turn the program over to Mr. Cumbea.

MR. CUMBEA: Thank you, Darrell. Good morning, ladies and gentlemen. Once more we reach that point in our annual proceedings which many consider to be a highlight of the meeting. This is your opportunity to test our panel of experts with any questions you may have relating to the papers that have been presented in the last two days, and any other questions relating to locomotive maintenance. I am sure the panel won't try to help you on how to get more on your expense account or explain lipstick on your collar.

The panel is made up of the chairmen of the six technical committees. As I introduce them I will ask them to give you a very brief review of the contents of their paper this year.

We will proceed in the order in which the papers were presented. Chairman of the New Developments committee; Chris Cox.

MR. COX: I will touch lightly on some of the topics we discussed. Our first topic was the application of microprocessing equipment for locomotives. We covered two major areas here. One was the microprocessing equipment used on board locomotives for diagnostic measurements of engine performance. The other area discussed was the use of the microprocessing equipment for in-shop use of computations of recorded data.

The next subject we touched on was locomotive warning light systems. We reviewed some of the past systems used for warning light systems, and we centered in on the most recent system, the strobe light, and discussed various railroads that are testing this, some of them in conjunction with the FRA.

The next subject was fuel conservation measurement. Two basic systems were discussed here for the measurement of fuel use, and that is the EMD system and the GE system. We touched on each one briefly and explained some of the differences between the two systems.

Another topic was the recording of events in locomotive and train operation. This system is relatively new on various railroads, and we reviewed the types of functions that can be derived from the systems and showed some of the capabilities of the systems. There are presently at least two systems being used, the Vapor system and the Pulse Electronics system.

The last subtopic we covered concerned new concepts in locomotive development. Under this heading we discussed a few of the new developments that are in use now, and improved traction motor and axle gearing, improved EMD gear case, engine pre-lube systems, other engine starting protection systems, blended brake system, and 42" diameter wheels.

We also listed a number of items that we thought were important in locomotive development with the use of new technology. We discussed briefly the GP40X locomotive and the TE70-4S locomotive using the Sulzer engine. In the future we hope to touch on a few of these topics again in new locomotive developments as a follow-up to see how they are coming along.

MR. CUMBEA: Next, Mike Gogol, Chairman of the Diesel Mechanical Maintenance Committee.

MR. GOGOL: The Committee paper's title was "Problems, Causes, Prevention and Repairs." It covered the EMD power assembly, diagnosis of failures to replacement of turbochargers, recommendations on winterization, an update on viscous dampers used on EMD's, main and connecting rod bearings, solid pressure fuel line progress by GE, air compressors and gear driven oil pump, and some comments on lube oil consumption on air compressors.

MR. CUMBEA: Next is the Chairman of the Fuel and Lubricants Committee, John Smalling.

MR. SMALLING: The Fuel and Lubricants Committee discussed the topic of "Problem Prevention Through Lubrication." The first subject we discussed was the relatively new sources of possible energy production, and questioned just how far in the future these advances could be made and also the expense involved in developing these sources.

The second subject was lube oil consumption test results that were run, and we discovered that this method of using the strontium 88 tracer was not sufficient and another procedure would have to be explored.

The third matter was Generation 4 lubricating oil; which shows there is another generation of lube oil arriving on the scene.

The fourth subject discussed was Locomotive Wheel Flange Lubricators and tests run at Pueblo that seem to have accomplished a good job as long as they were used.

The last topic discussed concerned the proper lubrication of locomotives throughout the entire railroad industry, and we learned that there is a wide variety of lubricants in usage for the same purpose.

MR. CUMBEA: Chairman of the Diesel Material Control Committee, Jim Gregory.

MR. GREGORY: This year we placed emphasis, as we did last year, on warranty. We emphasized that there is warranty on material obtained from the manufacturer, warranty on material sent out to outside rehabilitation, but more importantly the material that is repaired in the shop, because it is also important that we have warranty on material that we repair ourselves.

The second item we discussed was the justification for reclaiming heads, pistons, liners, and so on, and this of course depends on the economics and the approach you take to it.

The third topic was what we have learned from the material crisis of 1975, in which the GE representative brought out that if you plan your maintenance they can help you. If you don't plan your maintenance it has an adverse effect on both the railroad and the supplier.

The final item was the computerization of locomotive information systems which will help the maintenance forces.

MR. CUMBEA: Next, the Chairman of the Diesel Electrical Maintenance Committee, Carl Palme.

MR. PALME: In our first subject, Common Small Electrical Failures, we tried to point out a theme. While there is probably a category of twenty-five or thirty items we could put together, when we asked the various railroads to categorize the top ten there were not too many that were the same. We found we have the same basic small failure areas. We tried to give you some possible methods for solving these small areas which cause failure.

Under Traction Motor Maintenance, the theme here was not absolute values but that it is more important to look at your cost per mile than your initial cost of material. Certainly most of us look at initial cost in most cases, and actually cost per mile or cost in some other area is the way to finally evaluate performance as such.

In the ready track area there has been a lot of pressure lately to completely evaluate locomotives electrically on the ready track. The point we tried to make here was this: Before the unit gets to the ready track, let's have it evaluated so we don't have to spend the manhours at the ready track. Split the manhours in the shop where we can do preventive maintenance on these units.

In the modification area we tried to do as thorough a job as we could on the use of the GE or EMD locomotive as standby power. It is a very useful tool and it has a lot of capability. We put every bit of knowledge we could gather into that subject.

MR. CUMBEA: The Chairman of the Shop Equipment Committee, Elmer Hafling.

MR. HAFLING: In the past two years the Shop Equipment Committee has presented to this convention over seventy-five pieces of equipment that was either new or renewed to help decrease down time and increase maintenance efficiency.

This year's paper consisted of some more, either by updating or bringing new ideas on equipment such as fueling facilities, which is a never-dying item; painting facilities, which is also an important subject; new ideas on managing maintenance of machinery, which is a new concept. Also, new concepts in cleaning; radio controlled cranes, which is part of the maintenance equipment in your shops, and tools and tool control.

MR. CUMBEA: Gentlemen, this is your panel of experts. To start the questioning, I have one of my own that I would like to ask.

In looking over some proceedings to be held with the Canadian Board of Transport recently in regard to warning light systems for reduction of grade crossing accidents, we came across the term "gutter lights." No one in the group I was in knew what gutter lights are. Do any of our Canadian friends or supply representatives know what they are talking about?

MR. STRINGER: I never envisioned that this would be the first problem, but maybe the Canadian railroads started something that you may be hearing more about.

This is a pair of lights that we mount on the front end sheet of the locomotive. They cross about 250 feet in front of the locomotive, the idea being that it will allow the engineman to see around curves. The light on the right side front sheet shines off to the left, and the one on the left side crosses and shines off to the right. The purpose is to give the engineman better visibility around curves and in rock cuts.

Incidently, we also feel it does greatly increase the conspicuity of the locomotive. It is our position that these lights very effectively serve the same purpose as the flashing warning light that some of the states require be mounted up on the roof. These lights, because they are each a single powerful 350 watt 75 volt sealed beam light, have much less maintenance requirement than the flashing warning lights, and we are trying to boost their use for this purpose too. Principally, however, they are used to improve visibility around curves.

MR. LEEDY: I am afraid a lot of us are not as fuel conservation conscious as we were a couple of years ago. We are paying more for it. As indicated in the recent remarks, it is going to be 30, 40 or perhaps 50 cents. Going back to this gentleman's problem about fuel leakage, we probably have had thousands of gallons spilled this morning just while we have been talking here.

One question concerns the Houston system. That is the one I am most familiar with. Is the new electric system retrofittable to existing Houston fuel filters that we already have in service?

MR. HAFLING: Yes, that is compatible with the existing one now.

MR. LEEDY: Do you have any cost figures per unit?

MR. HAFLING: No, I don't, but I think there are some Houston people here, or at least they were here. How about Burlington Northern? ICG? I guess they aren't here.

MR. LEEDY: There is a problem with these automatic fueling systems. We got some servicing pads that have pumps that have 100, 200, 300 and 400, and I think some of them have 600 gallons per minute delivery. Does this have any overspilling effect if these things don't shut off promptly and effectively? Have there been any problems with the different fuel pump systems — fueling stations?

MR. HAFLING: I think on the old Snyder system they had trouble with high pressure, but I believe they overcame that with the new system. I don't know about Houston.

Also, it is determined by the number of nozzles you put on the system. If you have 200 lbs. and

put five nozzles on it, you will reduce it considerably. That is what we did with the Snyder system before we reduced the fuel pressure.

Can anybody answer that on the Houston system?

MR. LEEDY: My next question has to do with the warranty that was mentioned in Jim Gregory's report. He said it is in effect on the Burlington Northern and Conrail. When you employ this system with all of the records and all the written documents that go with it, does this mean you have to employ additional people to apply the system and maintain it, or do you use your existing materials people or shop people involved? Does it require additional new people to be hired to do it?

MR. GREGORY: I think any system you propose will involve more work. What we are trying to do at Conrail is to keep it down to a minimum, because we hope within a few months to have our warranty system where it is reported by the maintenance people, the same as they report the inspections they make, and it will go on the computer.

On the Burlington Northern, when they make out the form — and unfortunately Mr. Jacobson, who prepared the report, wasn't able to attend the meeting — in essence when the Stores people ship the material back to the backshop to be repaired, they use the same form that they previously used, but they make a notation on it that this is a warranty item, and one copy goes to the chief mechanical officer's department where it is evaluated.

In our department Quality Control will be the primary department involved, because they will make an inspection at the terminal of the material and then there will be a joint inspection made at the backshop by the backshop personnel and our QC personnel. We don't envision a lot of paper work, and I don't think the Burlington Northern does either. It will require extra work.

We are in the initial stage of this. By next year we hope to give the LMOA a full report on what we have saved by warranty, what warranty procedures cost us. That is about all I can say right now.

MR. LEEDY: You are going to give us a follow-up next year?

MR. GREGORY: Yes.

MR. FINDLING: This question is for Mr. Smalling. Do you now plan to include in your 1979 report on-board devices for refinement of fuel and lube oils?

MR. SMALLING: Yes, we do.

MR. FINDLING: I ask this because I brought this subject up earlier in the session and I now have a report. We do have an on-board oil master electro-refiner, manufactured by Correlated Oil Industries, Ltd. The report is extremely good. We have this on-board equipment on a GP40. Since it has been on there, fuel dilution has been decreased to .5% and total solids at 6.1%. The water percentage by volume is 6.5%.

Viscosity, 77.9%. Total base number has increased from 6 to 8.92, the pH from 7.9 to 10.

We are also investigating another area with a California manufacturer relative to refinement of fuel on locomotives.

This type of new development is interesting for the simple reason that we went to a higher grade of lube oil in order to take care of problems indigenous to GE locomotives carboning up, and so on. If there is any way to save money, this is the way to save it because you will maintain your base number and alkalinity and you will reduce the acids and other foreign material in the oils through this system. It could provide you during the wintertime with fuel that will not freeze up in the lines because the equipment will have removed the water content.

I have some other things I want to mention. Mr. Ingram challenged the locomotive builders to build a locomotive that didn't drip oil all over the landscape, and also to put component parts on skids so that they would be easily removable. Also, speed indicators would be a prime target. Speed indicators could be a subject for next year's paper, particularly in view of the fact that EMD does have a radar type speed recorder on the GP-40X's, and by next year there should be some good data available.

The other two areas are turbochargers and air compressors. It seems to me that everything deals with "We have got to do more and more things." It reminds me of the story about the airplane manufacturer who called his engineers and wanted to know why the engine on the airplane wasn't functioning properly. All of the engineers except one blamed it on the fuel. One of the engineers, who eventually became chief engineer, blamed it on the engine, and said, "We will have to change the engine so it can live with the fuel."

That is what is going to have to be done with turbochargers and air compressors. This list of things you have to do to make sure a turbocharger works is ridiculous. We should have turbochargers capable of operating for the life of the locomotive. We should have batteries capable of operating for the life of the locomotive, and air compressors also.

These are subjects I recommend for your consideration for next year.

MR. CUMBEA: Are you talking about speed indicators or recorders?

MR. FINDLING: Speed indicators.

MR. CUMBEA: We have taken note of your suggestions, and I am sure the Committees will consider some topics for next year.

I have a question from the Mail Bag: "What are the recommendations for lubrication of GE fuel layshaft bushings? Does anyone want to tackle that one?

MR. GOGOL: I will make a comment on that. I don't have the answer, but I might add to it. This is one area we found in need of attention. We thought we had governor, nozzle or pump problems. It turned out we had excessive wear on the shaft and bushings.

It all goes back to what type of lubricant is used. It takes a special lubricant, and it should not be washed out when you do any cleaning on the engine. We need a better lubricant to obtain better service life from this component.

MR. SMALLING: In line with this same subject, in our survey on proper lubricants over the whole railroad industry we found that some railroads are using unusual types of greases. In this particular instance Mr. Gogol just mentioned, we found that one location was using an automotive type grease for that purpose. You can see what might occur in an instance such as this.

MR. R. E. CLAWSON [General Foreman-Locomotive, Missouri Pacific Railroad, North Little Rock, Arkansas]: I would like to ask Mr. Gogol a question. When the EMD E3 engine first came out, it had a six-pack harmonic balances. They came out with a viscous damper. This gear type damper they are coming out with now — they have already recommended or suggested replacing the six-pack with the viscous in the rebuilt engine. Is there any indication of when this gear type vibration damper will be in production on locomotives or will be used to substitute for the viscous damper on rebuild?

MR. GOGOL: EMD is putting additional gear type dampers out in the field for trial, and they do not have the confidence yet from the service experience they have had with the ones in the field to make any standard. I understand the percentage of gear type going into the field is increasing monthly.

MR. CLAWSON: Is it going in production locomotives?

MR. GOGOL: I believe it is called a field trial. It is going into production on that basis.

MR. WECK: The last quarter of this year we will see production runs of gear type dampers in EMD locomotives. It will start in a given series and then work its way across the board as they become available.

VOICE: Will it be available for rebuild on railroads?

MR. WECK: I would assume so, as soon as the supply situation will allow.

MR. CUMBEA: Here is another question: "What is the maintenance policy for air compressor drive shafts—both Falk and Lord coupling—and how are these checked?" Does anyone wish to comment on their policy on air shaft drive couplings?

MR. GOGOL: I will make a general statement. Depending on the type of air compressor coupling, the ones requiring lubrication have scheduled lubrication period and they all have inducted service life that requires either changed out or the rubber bushings, dia-

phragms or coupling, depending on what type. Some of them require complete removal and repair at the bench before reapplication.

MR. HOLMES: In yesterday's discussion I was interested in the divergence of philosophies between the two engine builders and their methods of lube oil filtration, one requiring relatively fine porosity paper, 10 to 13 microns, and the other using the looser filter; I believe it was termed the long-life filter.

I don't know if Jack Hoffman is here, but it was my impression that in Jack's statements yesterday the responsibility for the oil cleanliness, per se, except for filtering the abrasives, is the total function of the lubricating oil. Evidently EMD's philosophy differs from this, in that they think finer filtration is needed in order to exclude not only the abrasives but some of the smaller organic particulates, which ultimately can result in carbonizing the parts.

A question to each builder: What is the advantage, from each builder's point of view, for his particular system?

Second, in regard to the lube oil, is it the GE philosophy with the long-life filter that the high performance lube oil or the fourth generation will be mandatory for successful operation of that system?

Is it probable or possible that some lube oil life might be sacrificed if the GE long-life filter is used with engine oils other than fourth generation? That is, could these unfiltered insolubles overwhelm the oil's dispersancy ability by changing the lube oil filters in 90 days with the end result being necessity to change lube oil in less than the normal time?

MR. SMALLING: I really don't think I should make a comment on that, but I do think the EMD or GE representatives who are in the audience should comment on it.

MR. KWIATKOWSKI: I will comment on the first point. The reason for the difference in micron size of the filters is by nature of the engine. The 4-cycle GE engine is dirtier than the EMD, and requires a filter media which has larger pores, whereas the types of contaminants in the EMD engine are much smaller and consequently need a much finer filtration system. Because of the particle size, the GE filter should not be used in the EMD system.

MR. CUMBEA: "How are the new low maintenance batteries that require very little water working out for railroads that have them?

Is there anyone using these low maintenance batteries? Would any battery manufacturers like to comment?

MR. ANTHONY BLADEK [Engineering - EMD, LaGrange, Illinois]: We started a project investigating low maintenance batteries. All the feedback we have received from the railroads so far indicates that there has not been enough experience with the calcium or low antimony batteries to draw any

conclusions. Our program is only about 8 or 12 months old.

MR. PALME: I know the Chessie has several sets of low maintenance batteries out, and we have the same problem. We have had them for about a year and a half or two years. We can't draw any conclusions. We will have to wait until the 6- to 8-year range. It seems to me the Santa Fe has had several years' experience. Can anybody from the Santa Fe comment? Bill Kelly has had much experience with them.

VOICE: We have had them for as long as three years on Conrail and we haven't had to water any of them. The ones we have watched are doing very well.

VOICE: As the railroad industry has changed to the biggest portable warehouse in the world, have any of the manufacturers attempted to use that facility to ease any of our material crises? I wonder if any of the manufacturers have attempted to use this in order to help alleviate any of our material crises in order to use it as a warehouse for their material.

MR. GREGORY: No, I don't believe we have come across anything on that. As far as warehousing is concerned, as you know, at the Juniata Shops we are spending $15 million to modernize the facility. One of the items included in the budget is a system for better storage and handling of material. We will be putting in the new facility and we will utilize the cube, which means we will have equipment so we can store material clear to the ceiling, which is done by most industries now.

As far as any industry coming into the item you mentioned, I have no knowledge of it, but next year we will have one topic on the modern warehousing and distribution of material by backshops or by the railroads, per se. That will be one of our items next year.

MR. CUMBEA: I will go back to the Mail Bag for another question. "In regard to the use of 42" wheels on HTC trucks, has this aggravated the alleged tendency of this truck to derail?

Mike, I think you have some 42" wheels. Can you comment on that?

MR. GOGOL: All of our HTC equipped truck units have the increased capacity snubber, and when we keep the wheel diameters within the recommended limits we don't see any difficulty. The unloading by wheel diameter difference would be the same as with the 48".

MR. WECK: That question sounds like, "When did you stop beating your wife?" It has no answer.

MR. K. H. SMITH: Recently we have expanded the use of our 42" tires and we are now utilizing them in the EMD freight truck and have had good experience there. I think the other roads find that occasionally when the locomotive is on the ground they will save themselves on gear cases and brake rigging in addition to having a larger wheel diameter.

MR. MAX EPHRAIM [Engineering, EMD, LaGrange, Illinois]: If the 42" wheel is used and the recommended wheel size variations are followed, there are no differences with regard to any derailment tendencies. I would caution, however, that there are many railroads represented here today that do not match wheels in many cases, and when you do get a 42" wheel on one axle and some badly mismatched wheels on the other axles, yes, there is more tendency to derail. That ought to be known.

MR. CUMBEA: Another question from the Mail Bag: "Why not just one lubricant for air compressors?"

MR. SMALLING: It is interesting that you asked that question. This is going to be a topic for next year's presentation by our Committee. We have learned that a lot of railroads are using different weight oils, so we plan to delve into this. If anyone should have any information on the subject now, we would like to hear it.

MR. CUMBEA: This goes back to Mr. Ingram's challenge: "Has anyone developed a system for more effectively washing locomotives?

MR. WHITTEN: I don't have an answer to the question right now, but next year the Shop Equipment Committee is going to review the washing of locomotives again, and hopefully we will be able to find some answers to that question.

MR. CUMBEA: I know the Southern has some pretty clean locomotives. Would anyone here from the Southern care to comment?

MR. WALKER: I guess I am the only one here. The Southern has had automated washers for a long time. I don't really know what the other railroads are using, thus I don't know how to compare them. We have a very satisfactory system. Maybe a committee would like to look into this next year and make a report.

MR. HOLMES: I wonder if Mr. Walker has any comments to make on their new system that they have had in operation for a while, on plastic coating of locomotives to make them shine better and protect the paint.

MR. WALKER: We are using the system. It does make the locomotives shine and stand out beautifully. It has some drawbacks. One is that you had better keep it off the windows. It will wipe off immediately after you put it on if you keep your laborers on the ball, but if left on the windows to dry it leaves a film that causes some visual problems for the engineer.

MR. CUMBEA: "EMD recommends lithium type gear case lubricant, while a number of supply representatives predict unfavorable results if used. Can anyone advise the pros and cons for lithium gear case lubricants?

These questions seem to be tieing into next year's topics.

MR. M. B. ABERNATHY [Continental Oil Company, Houston, Texas]: I believe I am correct in saying (and I think EMD will bear me out) that the change to lithium based grease was prompted by its ability to live with water more than anything else. It is predominantly in the same viscosity range as sodium based traction gear greases, and in most cases they have increased the EP and anti-wear characteristics of the grease to where the performance is better, with the viscosity about equal to that of the old sodium soap greases. Lithium soap lives with water very well.

MR. HOLMES: Has EMD found any difference in improvement on gear life with the use of these lithium based greases? It is my understanding that the first railroads that used this grease found it gave better gear life. Does EMD have any data on that?

MR. EPHRAIM: I am not sure which railroads you are referring to. There were some railroads that had gear life problems with some questionable lubricants, and in those cases of course the lithium based grease was a difinite improvement.

We think the lithium based grease in today's operating conditions is the best available, and is particularly helpful where high pressure wheel washing equipment is being used, since small amounts of water can be very harmful to sodium soap greases but do not affect the lithium soap grease.

MR. CUMBEA: Is there a better chance for lithium based greases to stay in the gear case than the old crater compounds, and less leakage?

MR. EPHRAIM: When one mentions crater compounds, there are different combinations of crater compounds and several different numbers, so it would be hard to give you a definite answer. If there is any grease in the gear case you have to have a good gear case and keep it tight if you want to retain the grease.

Viscosity of crater compounds also varies widely with temperature and degree of oxidation. The lithium soap grease is much less sensitive in these areas, and further is manufactured to a closely controlled viscosity range. This all adds up to better lubrication and probably less leakage than crater in a properly assembled gear case.

MR. CUMBEA: "What is happening in the area of fuel saving by isolating trailing units when not needed to maintain speed instead of throttling off all units?

MR. WESTERFIELD: That is a can of worms, to put it mildly. Earlier this year the Federal Railway Administration published the results of three tests where they attempted to make multiple runs with and without the isolation of units under different types of operation and different types of trains and different terrain. They found improved fuel savings in one operation, increased fuel consumption in another operation, and questionable results in a third operation.

I think all of us are in a position now where we are doing a little more extensive and more accurate testing than perhaps we did a year or two ago. I think I would have to say that the jury is still out on this. There are certain types of operations — for instance, back-haul on coal trains — where there may be definite savings, but I think this thing has been over-played a little bit.

MR. FRANK D. BRUNER [Assistant Chief Mechanical Officer-Research and Development, Union Pacific Railroad Company, Omaha, Nebraska]: This was discussed last year, at which time I advised that the Union Pacific had made a number of tests indicating the fuel saver concept could save fuel, and I would like to bring you up to date on further investigation of results of subsequent tests.

During this last summer a more extensive and complete test was run on the Union Pacific involving our test department, test car, and jointly participated in by EMD representatives and test department personnel. Over 30 comparative runs were evaluated, utilizing power with and without "fuel saver" operation on a track segment west of Laramie, Wyoming. The purpose of this test was to develop if there was a difference in thermal efficiency of a locomotive consist when running in both modes and maintaining the same speed.

All data collected was analyzed, and the results of these tests have been released by EMD, which indicate that there is no improvement in thermal efficiency of a locomotive consist in "fuel saver" mode and may in some cases slightly increase fuel usage.

At the time EMD reports that favorable results of previous tests were no doubt due to reduced running speed or the reduction of drag braking and/or excessive braking when approaching curves under power.

In further analyzation of the "fuel saver" mode operation on the Union Pacific over the last year, and the fact that the Union Pacific total fuel consumption has been reduced between 1% and 2% reflects that its use may have indeed saved fuel as the original tests indicated, and we were still able to maintain train schedule with slower running speeds.

Another thing brought out in these tests which should be of great interest to all railroads is the adverse effect on fuel economy due to frequent drag brake applications. We are one of the roads that rely on drag braking to control slack, because we have many territories with either undulating track or curve conditions. Our operating procedures throughout the years have called for use of drag braking to control slack.

After leaving this meeting yesterday, I dropped into the fuel and operating officers' meeting and was fortunate to catch the latter portion of a paper being presented to their group by one of the Canadian roads. They have not operated the "fuel saver", per se, on their property, but had made computer runs utilizing their master mechanics (counterpart to our road foremen in this country) and were able to show that different engineers under the different operating conditions of simulating "fuel saver" use could save considerable fuel.

As was stated earlier, the jury is still out; and regardless of how fuel is saved, the original objective on the Union Pacific was to put these devices on and utilize a fuel saving mode while maintaining train schedules. We have not tried to maintain a predetermined train speed or tried to take engines on and off the line for this purpose, and therefore we believe we have saved fuel as a result of modified operation and with slower train speeds, less drag braking and curve braking, wherein excessive energy is used.

The problem with making a final decision is that there is an expense and also time required to train engineers and operating people to control train speeds and horsepower to tonnage ratios to approach the best fuel economy. We believe that at least part of the reduction in fuel use by Union Pacific has been through the use of fuel saving devices presently installed, and would question the arbitrary removal of these devices because controlled speed tests have developed no resultant thermal efficiency. It would not make much sense to remove the device for an interim period while training crews and changing operations to save fuel and find in the interim our fuel consumption going up by even ¼%. In the case of Union Pacific this increased consumption could cost over $1 million per year.

I hope I have given you a clearer understanding of our situation and the reason why a final decision is being delayed. I am certain we will continue our studies, and I am also sure our management will be very thorough in their analyzation, as they are still determined to save fuel as in the past, and whatever this takes to accomplish will be done.

MR. EPHRAIM: I might add a little to what Frank has said. The railroad that had made a simulated operation in the fuel saver and non-fuel saver mode of operation actually had a practice of raising the locomotive throttle notch to a high throttle position during stretch braking. That was their normal practice. With stretch braking and some units isolated in the consist, obviously they had less tractive horsepower when using stretch braking. This gave them fuel savings.

It is a very realistic saving if that is the way the locomotives are going to be operated. The question is then whether the operating practice can be changed to go to a lower throttle notch during stretch braking and thus save fuel that way.

As Frank pointed out, there have been enough tests conducted. There are no thermal efficiency improvements using the "fuel saver." In fact, in many cases there might be a 1% or 2% loss, but it is very difficult to measure. There has been enough work done to say that if you have kilowatt-hour meters on the locomotives, the fuel used per kilowatt-hour in either the fuel saver or non-fuel saver mode will be so close you can't see the difference. We wish there was a saving. There isn't. Train handling does affect fuel consumption, and this needs more study by the railroads.

There is a device being marketed to maintain train speeds by using the fuel saver, by letting units in the locomotive consist cycle up and down. I think this is a very hazardous operating condition, because in some cases at intervals of 1, 2, 3 or 4 minutes they have locomotives cycling between no load and full load. This is NOT the way a locomotive should be operated.

One other thing is that in operating the trailing units in run 1, some people feel they have wheel slip protection. In most cases they do not have wheel slip protection in those trailing units in run 1. That also ought to be known.

MR. CUMBEA: "It is noted that many railroads report using thin oil in governors. Is engine hunting or loss of RPM noticed when units operate in high ambient temperatures?"

MR. SMALLING: When we went to a lower grade oil on our air compressors we decided to use the same grade of oil on the governors. We tried it but we had problems on governor operation, so we switched from the lower weight oil back to the 30 weight. That solved the problem we had in this respect.

MR. CUMBEA: Because we have to leave this room shortly so that it can be made ready for the luncheon, if there are no further questions I will turn the meeting back to Darrell Walker.

MR. WALKER: As I look around the room and see the fine attendance, I would like to say thank you for showing up. Usually attendance starts dwindling off this time of the week.

The experts were here to answer your questions. Several questions were asked that the GE builder should have been able to answer. It is very important to the LMOA to have suppliers and manufacturers here who do have the expertise to answer our questions, and we will appreciate it if you gentlemen will continue to do that.

Now I would like to turn the meeting back to President Harley.

PRESIDENT HARLEY: I have a few very brief closing remarks. Our membership at the meeting: We had 345 members registered and 71 ladies, totaling 416, which I think is very good when you consider the potential disaster that faced us as late as last Friday.

We also signed up 86 railroad members for 1978 and 51 associate members, for a total of 137, which of course has gone a long way toward easing our deficit.

We also have gotten for 1979, 78 railroad members and 48 associate members, for a total of 126, which will give us a very good start on our next year's membership.

The annual meeting next year will be somewhat different from this one. It will be held on September 15-19, 1979. It will start on Saturday because next year is an Exhibit year, and the exhibits actually open on Saturday and continue on Sunday. The meeting will begin on September 17 and continue through the 19th. We will meet at the Conrad Hilton Hotel, which will make it considerably handier for the track exhibits and easier from the standpoint of charges for rooms.

I would like to thank all of our officers and members for an excellent program this year, and in particular our able Secretary-Treasurer, Joe Koerner. I also want to thank our recorder, Charlotte Emmons, for her usual fine job. She has helped us out for many years, and we certainly appreciate it.

There will be an executive meeting in the Columbia Room right after the RSA luncheon. I hope all members of the Executive Committee, Vice Presidents and committee chairmen will be able to attend this very important meeting. We will try to finish our work as quickly as possible. There will be some continuing work done tomorrow, but it will be finished before lunch.

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

[The audience arose and applauded.]

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

PRE-CONVENTION PRESENTATIONS

INDEX

LOCOMOTIVE MAINTENANCE OFFICERS ASSOCIATION

INTERNATIONAL BALLROOM (SOUTH)

MONDAY, SEPTEMBER 17, 1979

TUESDAY, SEPTEMBER 18, 1979

WEDNESDAY, SEPTEMBER 19, 1979

ATTENTION EVERYONE COMING TO THE MEETING!

REGISTRATION FEE AT ANNUAL MEETING $5.00 PER MEMBER

LADIES FREE

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

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 1979 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." ALL HOSPITALITY SUITES CLOSE AT 8:30 A. M., 1:45 P. M., 11:00 P. M.
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.

OUR OFFICERS

E. T. HARLEY
PRESIDENT
Vice President - Equipment
Trailer Train Company
300 S. Wacker Drive
Chicago, IL 60606

F. D. BRUNER
4th VICE PRESIDENT
(General Membership Chairman)
Asst. C.M.O.-Research & Dev.
Union Pacific Railroad
Omaha, NB 68179

MEMBERSHIP THRU THE YEARS

	Advertisers	Associate	Active	Total
1939	0	27	60	87
1940	34	48	162	244
1941	38	48	210	296
1946	103	187	676	963
1947	101	284	937	1321
1948	113	295	1183	1591
1949	134	595	1789	2521
1950	123	595	2101	2822
1951	125	626	2912	3663
1952	135	510	2747	3392
1953	118	597	3288	4003
1954	118	545	2943	3606
1955	81	434	3235	3750
1956	110	419	3257	3786
1957	100	423	2678	3201
1958	82	350	2320	2752
1959	90	387	2395	2872
1960	98	393	2302	2793
1961	101	348	2201	2650
1962	118	316	2291	2725
1963	125	275	2345	2745
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

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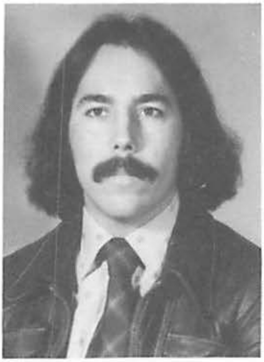

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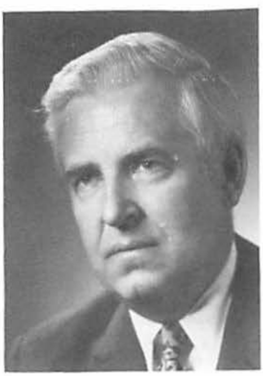

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Chicago, IL 60603

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Phone (304) 523-7276

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Monday, September 17, 1979

10:15 A.M.

REPORT OF THE COMMITTEE ON DIESEL ELECTRICAL MAINTENANCE

Pre-Convention Presentation: Chicago Railroad Diesel Club

April 2, 1979
Midland Hotel
Chicago, IL

H. G. F. STRINGER, Chairman
Supervisor Motive Power
Canadian Pacific, Ltd.
Room 903, Windsor Station
Montreal, Quebec H3C 3E4

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1979 TOPIC:
"OPTIMIZING THE PERFORMANCE OF THE LOCOMOTIVE ELECTRICAL SYSTEM"

PERSONAL HISTORY

HAROLD STRINGER

Harold Stringer was born on May 26, 1933, in a small town called Revelstoke which is located in the Selkirk Mountains of British Columbia.

Revelstoke is a divisional point on the Canadian Pacific Railroad and will be remembered as the home of the powerful Selkirk steam locomotives which were used on the mountain grades.

Although Harold's father was a school principal the lure of the railroad was too much and he joined Canadian Pacific as an apprentice in 1950. Leaves of absence to attend the University of British Columbia extended this apprenticeship until 1958. Following this, Harold spent several years as a Road and District Electrician on C.P's Pacific Region before being transferred to the Chief Mechanical Office in Montreal as a Mechanical Assistant in 1964, Senior Mechanical Assistant in 1968, Assistant to Engineer of Motive Power in 1972 and to his present position as Supervisor of Motive Power in 1974.

Harold is married to the former Ruth Buettner, a nurse, has two children and lives on a farm, located 45 miles south of Montreal, which is his principal hobby.

I.

LOCOMOTIVE BATTERY CHARGING SYSTEMS

Reflections on the problems associated with winter railroading, particularly when viewed in light of the experience of the last three years, are bound to bring up questions regarding batteries and battery charging. The questions generally take the form of, "Why won't the bleep-bleep batteries crank the engine?" The batteries are invisible, until they don't work.

What went wrong? There are two factors involved, which bear discussion in regard to battery operation: (1) the battery charging system (i.e.) charging voltage and (2) battery temperature. These factors are inter-related to some degree, further complicating the matter.

Battery Charging System

Battery charging systems include three major sub-systems:

1. A source of power - on locomotives, an engine driven auxiliary generator.
2. A regulator to control charging rates.
3. Protective devices such as fuses, circuit breakers and reverse current rectifiers.

The auxiliary generator may be of two types: either a conventional D-C brush type generator or a so-called "brushless" A-C generator, which is actually two machines in a common frame; an exciter, with D-C fields in the frame and an A-C armature on the rotor with diodes to rectify the A-C into D-C for the rotating field of the generator; and, the alternator, which supplies three-phase A-C which can be rectified to charge the batteries. A small current in the exciter field can control a large A-C output.

The regulator is used to control the output of the auxiliary generator to obtain the desired charging rates. Charging may be by constant current or constant potential methods. In the constant current method, a constant charging current is forced through the battery until it is fully charged. This method has the disadvantage that as the battery nears full charge, heavy gassing occurs and most of the charging energy goes into heat and gas, rather than into the battery. Therefore, the usual practice is to reduce the current near the end of the charge by limiting the maximum voltage that may be applied to the battery. The General Electric regulator and McGraw-Edison regulator, used with a current limiting module, utilize the constant current method of charging.

In constant potential charging, a constant voltage is applied to the battery through the charge. As the battery becomes charged, the current decreases until the battery is gassing and fully charged. The major disadvantage of this method is that a dead battery may draw such high current that the battery, wiring or the generator may be damaged. To overcome this problem, a low value, high wattage resistor is inserted in the series with the auxiliary generator to keep the charging current to a safe value. It is then necessary to raise the generator voltage slightly above the battery voltage to compensate for the voltage drop across the resistor at full charge. The EMD system is of this type, referred to as the modified constant potential method.

In both of the descriptions above, the battery is fully charged so that it gasses freely, then the charger is removed. When a battery is to be continuously connected to a charger, gassing is not desirable. In this situation, the battery is "floated" at a voltage just below the voltage at which gassing begins. While this reduces the water consumption, batteries on float are NEVER fully charged. To prevent deterioration, the battery must be given an occasional "equalizing" charge to make the specific gravity readings in all cells the same.

The principal factors influencing the charging system's ability to maintain the batteries are the charging voltage selected and the temperature at which the battery operates.

Charging Voltage

Depending on the type of battery, the manufacturer may recommend from 2.20 to 2.40 volts per cell at the battery terminals. The charging current will be doubled or halved by a .05 volt per cell change. Perhaps more important than what voltage is used, is that the voltage be accurate so that consistent results are obtained. The optimum charging voltage also varies with temperature, at about .006 volts per cell per °C or nearly

6 volts for a change from 25°C to -5°C. At -20°C, the charging voltage would have to be in excess of 80 volts.

The setting of the charging voltage is a compromise between water consumption and the time between equalizing charges. It is necessary periodically to "equalize" the charge by increasing the charging voltage by about .1 volts per cell, until there has been no change in specific gravity for at least two hours. The degree of variation in specific gravity from cell to cell is the clue as to when the battery requires equalizing. Research has also shown that the battery is benefitted by an occasional full discharge and "full" charge, where the battery is gassing freely at a voltage of 2.5 volts per cell or higher. There is no such thing as a maintenance-free battery.

Most D-C auxiliary generators appear capable of maintaining the reqúired float voltage, regardless of loading up to the rated value. These loads include:

Electric cab heat	8-10	KW
Main generator field (D-C types)	3-5	KW
Alternator field (EMD)	1.5	KW
Headlights	1	KW
Auxiliary generator field	1	KW
Battery charging	1	KW
Water cooler	.5	KW
Warning beacon	.2	KW
Controls	.2	KW
Other lighting	.2	KW
Radio	.1	KW

Additional items may be added by the individual railroad. The "brushless" A-C auxiliary alternator does not maintain float-voltage across the range of engine speeds.

The EMD 18 kw A-C auxiliary generator has been available for application since 1970. When originally developed, the only idle speed utilized was 308-315 rpm, and the A-C auxiliary generator could provide full 18kw at 74vD-C. The voltage regulator — VR11 — developed for use with the A-C auxiliary generator was recognized by EMD as having a speed/load voltage droop characteristic as opposed to a constant voltage level throughout the normal engine speed range. The A-C auxiliary generator output at standard idle would be in 68 - 72v D-C range instead of 74v D-C. However, during the same time period as the development and application of A-C auxiliary generators, the battery manufacturers were advocating/recommending reduced charging voltages (below 74vD-C) to minimize battery watering requirements. Hence EMD felt the VR11 speed/load voltage droop characteristic was desirable with respect to the battery manufacturers' recommendations, and the droop characteristic was not eliminated.

Some roads have reported incidents where units operating in cold weather have had batteries freeze. This situation will be particularly acute on units equipped with electrical cab heat and/or the low idle fuel saving option. It is the committee's understanding that this matter is being reviewed by EMD and pending the results of further testing we suggest that caution be exercised when operating A-C auxiliary generator equipped units in severe cold weather situations.

At present, EMD has very active development* programs for the VR11 regulator to provide a flat 74vD-C voltage characteristic between normal idle and full speed. Project regulators are expected to be on field test by Fall of 1979. Although the project VR11 with flat voltage regulation characteristics will not be able to provide full 74vD-C at low engine idle speed (250 rpm), the voltage level will be higher at low engine idle than that provided by VR11 with the voltage droop characteristic. EMD also has development programs underway to improve charging voltage levels at low engine idle speed.

Temperature

The effects of low temperature are described in the table, but can be summarized in one word: **bad.** Specifically, the increased resistance may make it impossible to supply breakaway current to the starting system. The decreased total capacity may not permit the battery to achieve minimum engine firing speed. Further, a single start in severe conditions may use so much of the battery's reduced capacity, that several hours will be required to recharge. If another start is required before the battery has recovered, it will fail to perform.

Effects of Decreasing Temperature

Open circuit voltage	Decrease
Internal losses (local action)	Decrease
Resistance	Increase
Charging voltage required	Increase
Ability to accept charge	Decrease
Water consumption	Decrease

Measurements of electrolyte temperatures during severe weather have shown that the batteries are at ambient air temperature.

Recommendations

A battery is as strong as its weakest link or cell and less than ideal battery maintenance practices will reap their true reward during severe weather operations. Some other observations:

1. Lead calcium batteries have lower internal losses (local action), thus a greater percent of the charging current goes into maintaining the charge. This extends the interval between equalizing charges, as well as extending watering intervals.
2. The ultimate solution to low temperature problems is to keep the batteries warm — perhaps easier said than done. A 15°C. increase in temperature would at least double the battery capacity with minimal danger of overheating.
3. The present state of battery specifications is unsatisfactory, to say the least. Some 19-plate batteries have higher rated cranking capacities than

some 23-plate batteries. Also, capacities given in 8-hour rates at room temperature are meaningless for cranking an engine at -20°C. Some standard rating, which would relate to cold weather cranking ability and builders' requirements, is needed.

The committee urges the battery manufacturers to adopt more meaningful standards for the measurements of the engine cranking power that is available from their products at various electrolyte temperatures. The following proposal is suggested as a starting point for discussion: —

"The battery should deliver not less than X amperes for 1.5 minutes continuously at not less than Y volts with electrolyte temperatures of 0°C and -20°C."

These same types of criteria, given for a typical 5 second initial breakaway cranking interval, would also be of great interest.

II.

COLD WEATHER LOCOMOTIVE SHUTDOWN PROTECTIVE SYSTEMS

With the increasing cost of fuel oil every effort is being made to minimize the number of hours that diesel engines are operated. A typical high-horsepower locomotive burns about 5 gph at idle and the savings that can be generated by eliminating unnecessary idling can amount to several thousand dollars per unit per year. Indeed, as the supply of fuel oil diminishes, it may become necessary to maintain all locomotives in a shutdown condition at all times when they are not actually pulling a train.

Shutting down and restarting locomotive engines presents no unusual difficulty during warm weather and this practice is being followed extensively by most railroads.

During cold weather, problems are encountered in trying to keep the engine coolant from freezing in pipes and auxiliary systems such as cab heaters and air compressors, and in maintaining the engine block and lubricating oil at a high enough temperature to permit engine cranking.

In order to allow engine shutdown in cold temperatures, several systems for layover protection have been developed and these will be described briefly.

Vapor

The Vapor system, currently being heralded under such patriotic terms as the "Scotch Watchman" or "Conservationalist", consists of a gun type oil burner similar to that of a household furnace, heat exchanger and auxiliary pumps that permit the circulation of both fuel and lubricating oil. This unit consumes fuel at the rate of 1.65 US gal/hr. and has a 150,000 BTU/hr. maximum output.

The Vapor heater sells for about $5000 (US) and requires about 160 hrs. for installation and about $1200 for additional material, making the total installed cost for a

typical EMD unit on the order of $7800.

The Vapor unit requires 115/220 volt wayside power circuit of 30/15 ampere capacity respectively.

It can be supplied with an optional battery charger and has automatic control and shutdown alarm features.

Kim

A second type of heater, produced by the Kim Hotstart Manufacturing Co., differs from the Vapor system in that it is an all-electric system and does not consume diesel fuel from the locomotive. These units have been used previously in off-highway vehicle and standby power plant applications and are now available for locomotive application with a heating capacity of up to 18 kw (68,000 Btu) or 24 kw (80,000 Btu) for special systems.

The Kim uses an electric heat exchanger and employs separate pumps to circulate the engine coolant and lubricating oil.

This unit requires wayside power facilities of sufficient capacity, and the cost of providing these must be taken into account if they are not already in place.

The cost of an 18 kw Kim unit is $3000 (US) with about 80 hours required for installation and $500 for additional material for a total installed cost of $4300.

EMD and GE

The committee has been advised that custom-designed standby heating facilities are available from both locomotive builders for their respective units; however, applications to date have been limited to a few carbody type passenger units in commuter service.

A GE application on a commuter unit operated by the State of New Jersey on the former Erie Lackawanna consists of 12kw of immersion heaters, a 1/6 hp water circulating pump and a trickle charger for the locomotive batteries. These are operated from 480 volt 3-phase wayside power. Due to the relatively short term of the layover, less than eight hours, heating of the lubricating oil was not considered necessary for this installation.

It is interesting to note that this application was prompted by a necessity to reduce noise in the area where this unit would normally have been idled and this, in addition to the fuel saving, can be considered as an advantage for installing a layover protective system.

A special EMD layover protection system was designed and applied to F40C and F40PH locomotives used in the Chicago area commuter service wherein extended shutdowns which occur over weekends is a normal operating mode. The EMD system was designed to provide extended shutdown protection for systems requiring it down to -20°F ambient, and still allow engine start-up.

All systems are designed to only operate when the locomotive is shut down and an external source of three phase 480 VAC power is provided.

FIG. 1
Vapor "Watchman" Standby Heater

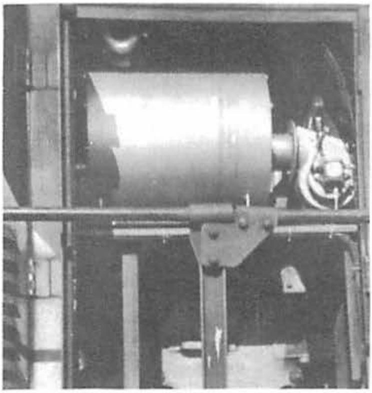


FIG. 2
Typical Application of a Vapor Standby Heater to an SW1200 Unit

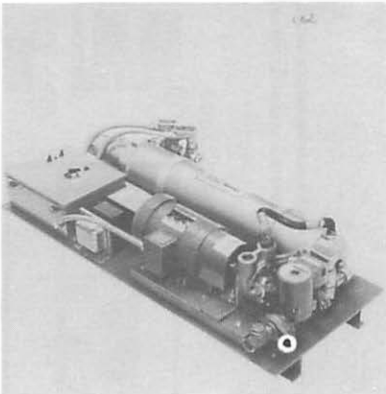


FIG. 3
Kim Hotstart Standby Heater

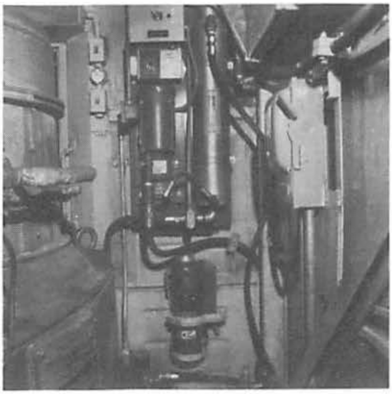


FIG. 4
Application of Kim Hotstart Heater to an F7 Unit

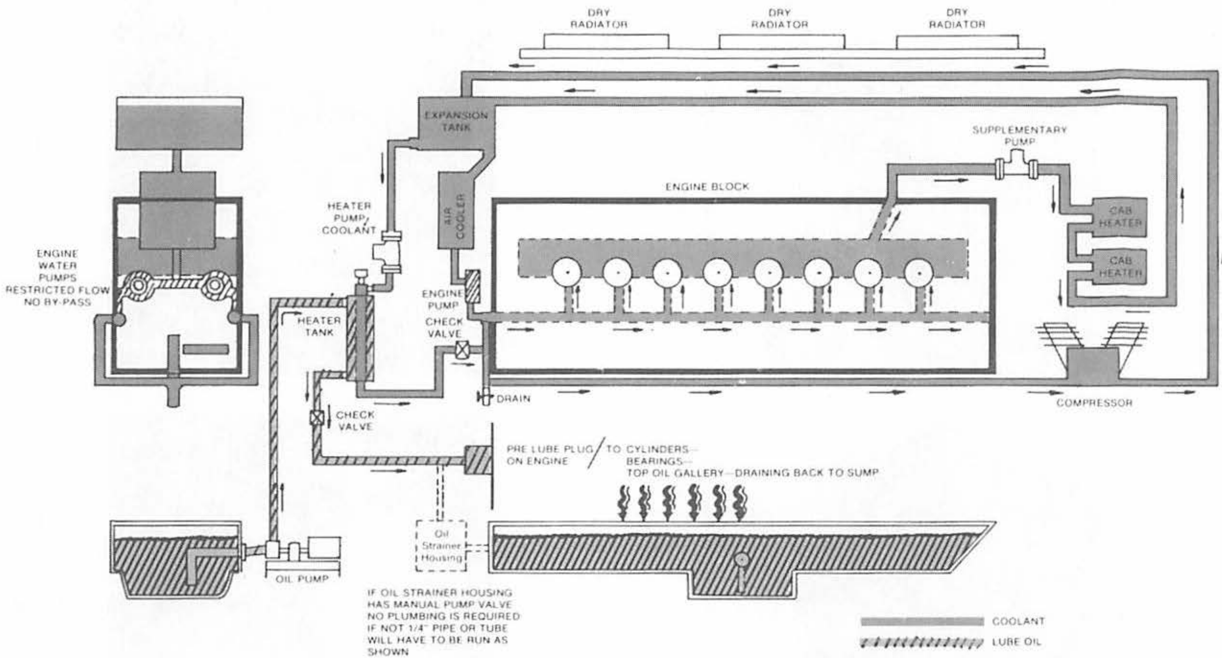


FIG. 5
Engine Water and Lube Oil Standby Heater Pump Arrangement

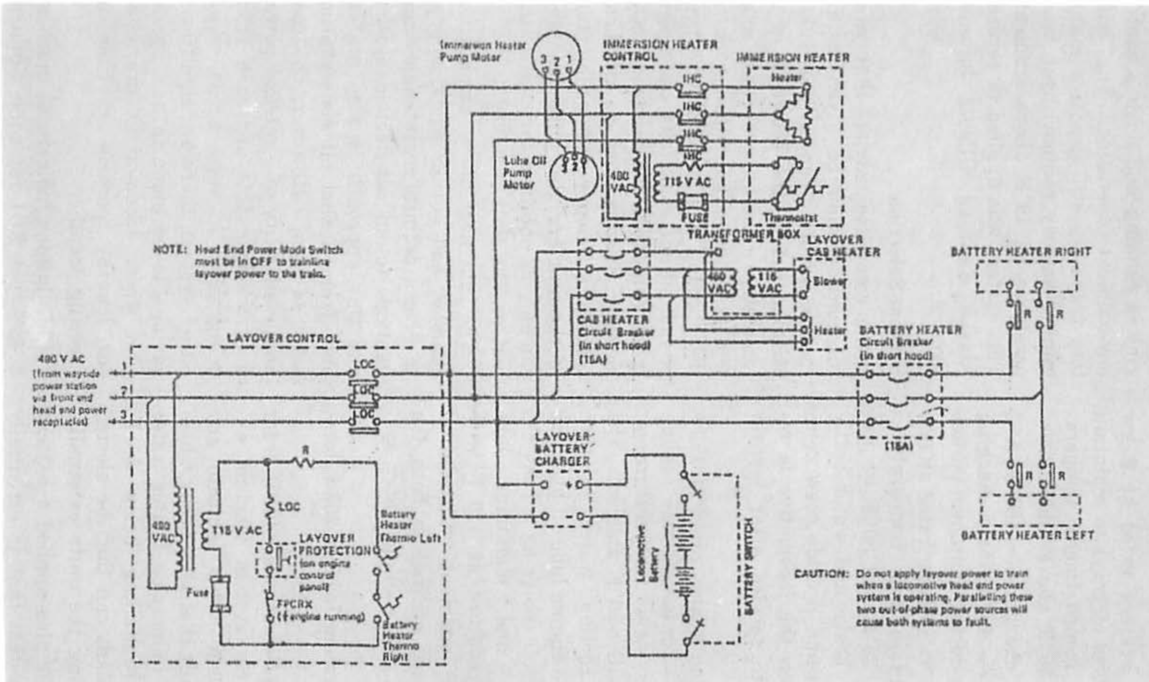


FIG. 6
EMD Layover Protection System As Applied to F40PH Locomotive

The systems applied to each locomotive include the following:

—Battery heaters rated at 2 kw in the form of trays to maintain battery compartment temperature at 40°F above ambient.

—Battery charger — 480 v A-C powered — for battery charging purposes during shutdown period.

—Separate cab heater rated at 4kw to maintain cab temperatures between 70°F and 80°F to prevent air brake and water bottle freezeup and provide crew comfort when the locomotive is returned to service after layover period.

—Immersion heater rated at 15kw to heat/maintain engine cooling water system temperature at 115°F with -20°F ambient. The heated cooling water in turn heats the engine lube oil by using the lube oil cooler as a heat exchanger and maintains lube oil temperature at 110°F with a -20°F ambient. Circulating pumps are utilized in both the lube oil and cooling water systems.

Total system load is 25kw/locomotive.

Also applied on one F40PH order is an alarm system wherein external alarm lights indicate any system fault that may occur which results in immersion heater water temperature falling below 55°F. The attendant can then be alerted by observing the units externally.

EMD has also applied a battery heating system that is essentially the same as described above except it is 74v D-C powered and only operates while the locomotive engine is running and during winter low-ambient operation. The battery trays are still used for maintaining battery compartment temperatures of 40°F above ambient. This system was applied to several Alaska Railroad GP40-2 locomotives.

System Selection

This committee advises that careful consideration be given to all factors involved on a particular railroad before the selection of a locomotive standby protective system is made. The initial cost of the standby unit and relative cost of fuel oil and electricity can readily be compared for a given area; however, factors such as the heat transfer efficiency and cycling time of the unit are also important and can only be obtained through actual test on the unit involved.

The absence of a combustion chamber and burner would appear to give a definite maintenance advantage to an all-electric system and this approach is also preferable from a fuel oil conservation point of view. However, the cost and availability of electrical power may preclude this approach from being taken in some areas. With either system, there are significant savings to be made in any operation where locomotives are idled for lengthy periods of time in freezing weather.

Calculations indicate as much as a 45% net ROI for some applications and the committee feels that

this important savings, both in dollars and in fuel oil should be fully investigated by all railroads concerned.

III.
ELECTRONIC SPEED INDICATORS

During the past several years, this committee has addressed itself to the electronic speed indicator and to the advantages the electronic equipment offered over mechanically driven systems. The initial reaction was that the electronic system did offer considerable maintenance cost savings. Electronic speed indicators have now been around for several years and have evolved into even a second and third generation series of improved units. Today, we have a plethora of analog indicator heads from 3-inch to 8-inch diameter, digital heads using LED or LCD segments, digital heads that read like a thermometer, have "all the works in a drawer", separate control modules, and separate indicator heads, and virtually any other combination or feature imaginable. Yet, there is one question which has not been answered: with all our experience with electronic speed indicators, have they proven to be the panacea they were purported to be?

One approach to this determination is to examine the money spent on maintaining electronic indicators. One railroad represented on this committee found that it spent slightly over $33,000 in 1978 to maintain 303 electronic speed indicators - an average of $2,782 per month. This figure does not seem excessive until one considers that this is for new material only, and does not include material sent out for repair, cost to repair material in-house, labor expenditures to repair and calibrate indicators; nor does it include materials handling for inventory stock, equipment returned to a vendor for repair, or spare parts stocking costs for in-house repair. This approach did point out one thing — because railroad cost accounting is so broad in scope, relatively few companies in this industry can identify with any degree of precision the actual costs encountered in maintaining electronic speed indicators.

Along with this inability to allocate costs attributable to electronic speed indicator maintenance, it is also a fact that few railroads can even generate raw numbers of speed indicators repaired in a given time frame. This approach, then, cannot be expected to adequately represent the industry's experience with electronic indicators.

This leaves only "opinion response" as a means of evaluating electronic speed indicators. It should be pointed out that this type of evaluation is affected by the personal feelings of the people surveyed. However, when consistent comments such as: "The record of Brand V is dismal at best" and "the record for B's indicators is only marginally better" are obtained it may be safely assumed that the reasons behind these comments are deeper than personal feelings. Basically these complaints center around several areas concerning electronic speed indicators:

1. Reliability
   a. Excessive reports of bad order indicators
   b. Operating crew complaints of inaccuracies.
2. Maintenance
   a. Require an excessive amount of maintenance attention
   b. Axel drives are a continual problem
   c. Module reliability is not acceptable
   d. Excessive numbers of upgrades and retrofits
   e. Too many model changes in too short a time period.

Let us take a brief look at these complaints. One member road on this committee averages roughly six complaints per day concerning speed indicators being inaccurate or inoperable. The bulk of these complaints concerns electronic indicators. The size of this average tends to indicate a reliability problem. This, coupled with the maintenance requirement complaints, indicates that in spite of the generally accepted high maintenance attention given electronic indicators, the fixes are not lasting an acceptable amount of time. The complaints by operating crews concerning accuracy are also valid. Most engineers will accept plus-or-minus five mph accuracy. However, when a number of complaints of ten, fifteen, even twenty mph differences are received, the ability of speed indicators to maintain accuracy is also in question.

From the maintenance aspect, a common complaint is that despite the maintenance, repair, and calibration procedures that are applied to electronic speed indicators, the number of times these procedures must be applied has increased. This increase in maintenance attention movements offsets the reduced-time-per-attention advantage to a large degree. Basically, this means that reduced time to perform maintenance has been traded off for an increase in the number of times this attention is applied. Axle drives, which eliminated the maintenance-intensive right-angle drive and flexible cable, are a continuing problem. The environment these devices must operate in is one of extreme vibration and shock. The device is exposed to the elements, and to physical damage also. Yet the current failure rate on axle drives is not acceptable.

Another large portion of maintenance time is spent on troubleshooting inoperative or malfunctioning indicators caused by module or card failures. These modules and cards contain precision electronic components which again are components subjected to vibration, shock and temperature variations. In addition to this physical environment, the electrical environment on locomotives is known to be replete with noise, spikes, etc.; with resultant adverse impact on solid state devices on these cards such as IC's, transistors, etc. It does not seem unreasonable that the static portion of electronic indicators could be built with the highest quality MIL-standard components and spike protection throughout, and improve upon module reliability and stability. Such an approach, however, would expectedly place the cost of electronic speed indicators well beyond the range of acceptability in terms of price.

The fourth major complaint about electronic speed indicators is one centering around retrofits and modifications. Electrical maintenance engineers can well appreciate the manufacturers' efforts to improve their products on an ongoing basis. Nor would many complaints be directed to these retrofits and modifications in terms of first generation electronic indicators. However, succeeding generations of electronic indicators have also demonstrated a very annoying tendency to need retrofits and modifications, which does not speak well of the learning curves from previous problems. All too often, the marketing cart appears to be placed in front of the engineering horse. In all fairness to the manufacturers, it should be pointed out that they have been most willing to facilitate retrofits on a no-charge for material basis. However, the cost to the railroad industry of handling, policing, and monitoring these retrofits represents a sizable expenditure in manhours and paper work. Such programs also adversely affect the manufacturer's profit margin; and if this expenditure must be made, it should be expended in premarketing engineering and development as a preventive measure, rather than as an after-the-fact coping with the problem.

This is directly related to the fifth major complaint — too rapid a change in electronic indicators. The competition between electronic speed indicator manufacturers is severe, and there are feelings that this competition has been detrimental to the product quality. Too often, new generations of speed indicators appear before the problems with preceding generations have been solved (or in some cases to have even appeared). The rapid introduction of generation after generation of electronic indicators in a short time frame aggravates the above-mentioned retrofit and modification problems.

New Developments

There are two developments in the electronic speed indicator field which represent either new technology or new features. In this case, we are discussing something other than repackaging or other minor alterations of existing electronic indicators.

As noted earlier, a number of complaints have centered around the axle alternator used to drive the indicator. The technology to eliminate the axle alternator is available now, in the form of a RADAR (RAdio Detection And Ranging) operated indicator. The basic advantage of the radar driven indicator is that speed indicator accuracy is made independent of wheel size variations, and the attendent maintenance problems of the axle alternator are also eliminated.

First, let us examine how such an indicator works. It should be pointed out here that the radar technology referred to here is not the "echo-ranging" type used to determine a target's range bearing, azimuth, altitude, etc. The type of radar being demonstrated here is based on the Doppler shift principle, which basically states that an alternating current wave (either radio or audio) reflected by an object in motion is altered in frequency by an amount proportional to the speed of the object. The reverse of this is also true: if the source is located on a moving object and the transmitted signal is reflected by a stationary object, the reflected signal frequency is also altered proportionally in relation to the speed of the source. This is not as complicated as it sounds. Virtually everyone has waited at a grade crossing for an approaching train and heard the pitch of the horn rise as the train approached, then fall after it passes by. Many of us have also been unfortunate enough to be caught in a radar speed trap. These are both examples of the Doppler shift principle. In either case, the difference signals are measured and converted into miles per hour. Such a speed measurement system eliminates the axle alternator problems, and inaccuracy due to wheel size variation.

This equipment basically operates with a transmitter-receiver unit mounted underneath the locomotive frame, and directed at a 45° angle below horizontal. This module generates a difference frequency of approximately 22.5 Hz/mph from the transmitted and reflected signals, which is fed to a processing unit in the locomotive cab. The indicator, either digital or analog, is driven by the processing module. In the case of a digital readout, a provision can also be made to indicate deceleration or acceleration.

This new type of radar operated indicator eliminates several of the problems encountered with an earlier such indicator tested on the Illinois Central Gulf railroad a few years ago. Similar to the radar control on EMD's X-series locomotives, this device does show promise and warrants the attention of the rail industry. It is currently being developed by CMI, Incorporated.

A second electronic indicator is one which has some features not previously marketed. Developed by Freightmaster Research, a Halliburton company, the device is more than a speed indicator. Rather, it is a train dynamics analyzer and provides:

1. Speed indication in mph (digital)
2. Acceleration or deceleration (digital)
3. Resettable distance counter
4. Non-resettable odometer.

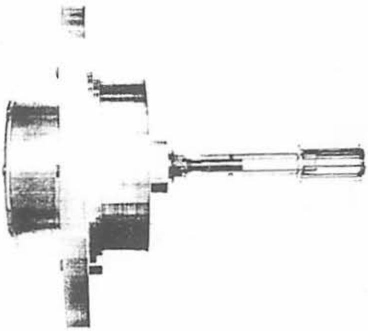


FIG. 7
End of Axle Transducer

FIG. 8
Indicator Box

The device uses an axle alternator drive (shown in Figure 7) and the indicator (shown in Figure 8) will display speed to the nearest .1 mph up to 99.9 mph. Acceleration is given to the nearest mph/min; if a negative sign appears in front of this figure, the displayed number is deceleration in mph/min. The resettable distance counter can be used in two ways. For example, if the engineman does not know the length of his train, he turns the distance counter on and selects the UP count mode. As he passes a mile post or other visible landmark, he momentarily throws the on switch to RESET and allows the counter to operate until the rear end crew radios that the rear car passed the same landmark. At this point, the engineman moves the "UP" switch to STOP. The indicated number is the train length in feet. The same counter may be used by dialing the known train length into the thumbwheel switches and placing the mode switch into DOWN. If, for example, the engineman wants to know when the rear of his train clears a given point, he momentarily places the switch in RESET and the total length appears in the readout. The count goes down from this indication, and when the counter reaches zero, the rear of the train is at the given point. The non-resettable odometer (shown in Figure 9) indicates total miles on the locomotive. Reverse operation does not subtract miles from the odometer, but adds them instead. Thus, the odometer indicates true mileage. This device does show promise as a train handling aid as well as being a speed indicator.

These two devices are examples of something new in the area of electronic speed indicators.

Summary

Based on the comments expressed by several representatives of

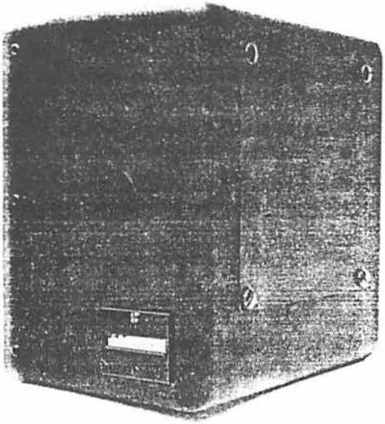


FIG. 9
Panel and Odometer

railroad industry electrical and maintenance organizations, there seems to be a general dissatisfaction with the electronic speed indicator in its present status. This dissatisfaction revolves around the maintenance attention required by these devices, their reliability and accuracy, and the continuing need for retrofits and modifications. In no case was any one specific manufacturer singled out. Instead, the complaints were expressed in a general consideration of the industry as a whole.

Why are these complaints deemed important? For two reasons. First, both federal and state regulatory and legislative bodies are considering (or have enacted) laws making operating and accurate speed indicators mandatory. This affects virtually every railroad represented at this convention. Second, pressure in the form of Section 6 notices has been applied by labor organizations representing the operating crafts concerning the condition of locomotive cabs, including speed indicators. Some of this labor pressure has also been directed toward the aforementioned legislative and regulatory agencies. The outgrowth of this will be an engineman's right to refuse a consist because of an inoperable speed indicator. One does not require much imagination to visualize the effect of this situation on train operations.

This committee feels that electronic speed indicators in their present state of the art place electrical maintenance personnel in a difficult position. On one hand, they must continually pursue the maintenance and upkeep of electronic speed indicators. On the other hand, regardless of the amount of maintenance performed, they still face a high enough percentage of bad order indicators to limit their ability to comply with either proposed or existing governmental requirements or operating craft demands. It is important to note here that it is simply not possible to legislate an operable, accurate and reliable speed indicator, and this committee feels that further legislation regarding mandatory speed indicators is ill-advised at this time. The electronic speed indicator industry needs to examine the performance of its products. The railroad industry needs to accurately ascertain in dollars and cents what it does cost to maintain electronic indicators. Together, they must exert whatever effort is required to ensure that electronic speed indicators become as maintenance-free and reliable as is technologically possible and within suitable cost boundaries. Without this effort, the lid may well come off Pandora's proverbial box.

IV

LOAD BOX TESTING

To make sure that the best use is being made of the fuel supplied to the locomotive, it is important to know that the locomotive is putting out proper power. If the dispatcher has to assign extra units to a consist to make sure it gets over the road, fuel is being wasted.

Load box testing is done for several reasons. The most common ones are:

1. Verify engine horsepower
2. Verify excitation and power matching or performance control
3. Break-in a new engine after overhaul
4. Special engineering test for fuel consumption, systems performance, etc.

The most common reason for load box testing in railroad maintenance is to verify engine horsepower.

This committee feels that load testing every road unit at least once per year pays off much more than its cost. It recommends that a regular schedule be established and competent people assigned to this job. It is important that records be kept to show the performance each time the unit is load tested. This will aid in showing trends in performance and aid in scheduling maintenance.

In order to be effective, it is necessary to measure more than just horsepower. It is recommended that a railroad make up a regular data sheet and use it as a guide to make sure that no data are overlooked. This should include volts, amps, ambient temperature, barometric pressure, water system temperatures and pressures, lube oil system pressures and temperatures, fuel system pressures and temperatures, intake air filter pressure drops, cooling system status as to number of fans running, governor position and load control potentiometer position, fuel racks, engine rpm, preturbo temperature, intake air manifold temperature, battery voltage, and other data of particular significance to the exact locomotive being tested. If desired, this procedure could also be expanded to record exhaust smoke, other exhaust emissions, noise level, precision fuel rate and other specific items that may be important to a particular railroad or area.

It is important to use good instrumentation and have it recalibrated regularly to avoid having bad data in the files. The current improvement in digital electrical meters makes them very attractive for load box use and they should be permanently assigned to the load box, and not left to wander off into other service in the shop.

The personnel at the load box should have a regular station for meters and equipment. Since this testing is frequently done outside, the test station should have a small building at the load test site with provision for good heat and light and the storage of schematics, tools, meters, etc. If this is not done, the testing cannot be very effective. Some roads have built this test shed at locomotive running board level to minimize the climbing of locomotive ladders. Many shops have a master controller from a scrap locomotive wired in so that the unit may be controlled by the MU jumper from the test shed. The entire operating cab of a retired locomotive can make an inexpensive operating control station, and a retired caboose might make a test shed. This is also valuable since it also checks out the trainline signal circuits. More units run in trail than they do in lead, and thus running it only from its own throttle station may miss something.

This is also a logical time and place to make an orifice test on the air compressor.

Although some roads run these tests around the clock, it is probably better to concentrate the good personnel on the day shift when observations are easier and more facilities are available. Other shifts may not be able to be as efficient and may pass something that should be questioned.

Some railroads are equipped with SEARCH machines and use that facility for this load testing. If they do, it is also recommended that the other electrical systems be tested. This would include transition control, wheel slip systems, excitation settings, and all of the other things that are already commonly done at the SEARCH building. We also recommend that current limit be verified to make sure that power matching or performance control do not interfere with the standstill tractive effort rating of the locomotive.

In order to do this it is necessary to provide a very low resistance point on the load box, and note carefully the short-time rating of the electrical equipment.

If a dead short is going to be bolted in place, make sure that the current measuring equipment in the locomotive is included in the short circuit path. If it is not, excessive current will surely result, with probable damage to the transmission equipment.

If SEARCH is not available, some of these same things can be tested by collecting the various testing equipment now in use at the railroad. This would include M-G sets for transition, axle alternator test kit, variable D-C voltage power supply and various minor tools such as injector setting gages, governor gap gages, overspeed testing tool, etc.

In addition to improving the locomotive fleet, load-box testing is a valuable teaching tool for newer employees who can be assigned to work with the regular load box personnel to learn and understand the overall workings of the locomotive.

V.

MODIFICATIONS

This item was instituted by the committee as a continuing topic in an effort to review some of the principal locomotive electrical modifications that are brought to our attention each year.

It is recognized that modifications are frequently a nemesis to the Mechanical department if the locomotive can be dispatched to haul tonnage without them. In forthcoming sessions it is hoped that this section of the committee will be able to provide some assessment of the need vs cost vs benefit to be derived from major modifications that are proposed by both the builders and member railroads.

Included in this evaluation might be proposals such as the application of electric cab heaters, the replacement of old style switchgear on some units or the application of more powerful 75 volt 350 watt sealed beam headlights.

Modifications are not to be confused with tests or projects that are intended to evaluate components or identify problem areas. Modifications are considered to be the application of proven or developed cures that are known to bring about improvement in the operation, maintenance or safety aspects of the locomotive electrical system.

It is felt that a comparison of results and experience by the various railroads will better help the committee refine the various modification proposals and develop the need vs cost vs benefit figures that will help establish a priority of application.

We intend to send out a survey or questionnaire regarding the policy and priority your railroad places on modifications. The questionnaire will also request a brief description of the modifications that have most enhanced your operation during the past few years.

As indicated, it is felt that the dissemination of such information will benefit the entire industry and the committee requests your wholehearted co-operation in this endeavor.

Monday, September 17, 1979

2:10 P.M.

REPORT OF THE COMMITTEE ON DIESEL MATERIAL CONTROL

Pre-Convention Presentation: Altoona Shops Consolidated Rail Corp. Altoona, PA

May 8. 1979 Sheraton Motor Inn Altoona, PA

D. L. WARD, Chairman
Engineer Motive Power
St. Louis-San Francisco Railway Co.
3253 E. Trafficway
Springfield, MO 65802

VICE CHAIRMAN

M. L. Wall, Mechanical Superintendent, Missouri Pacific Railroad, 502 Union Station, Houston, TX 77002

COMMITTEE MEMBERS

L. W. Bellon, Assistant to Director Purchasing & Materials, Atchison, Topeka & Santa Fe Railway, Topeka, KS 66601

C. V. Blessing, Manager Methods and Procedures, Consolidated Rail Corp., Philadelphia, PA 19104

F. A. Blundon, Regional Manager-Material, Burlington Northern, Inc., St. Paul, MN 55103

B. J. Cruise, Manager Electro-Motive Warranty Section, General Motors Corp., La-Grange, IL 60525

M. G. Dinius, Superintendent Locomotive-Mechanical, Illinois Central Gulf Railroad, Chicago, IL 60601

T. H. Field, Director Regional Material Centers, Southern Railway Co., Atlanta, GA 30303

R. B. Hall, Locomotive Department, General Electric Company, Erie, PA 16501

M. A. La Torre, Plant Manager, Southern Pacific Transp. Co., Houston, TX 77009

C. G. MacDermot, Assistant Chief Mechanical Officer, Delaware & Hudson Railway Co., Watervliet, NY 12189

L. C. Showers, Manager Cost Control, Union Pacific Railroad Co., Omaha, NB 68179

B. O. Vaden, Mechanical Supervisor-Locomotive, Norfolk & Western Railway Co., Roanoke, VA 24011

G. M. White, Regional Sales Representative, Alco Power, Inc., North Bergen, NJ 07047

1979 TOPIC:
"MATERIAL MANAGEMENT: DOLLARS SAVED THROUGH EFFICIENCY"

PERSONAL HISTORY

DONALD L. WARD

Donald L. Ward was born in St. Louis, Missouri, March 27, 1945. He attended grade school and high school in St. Louis, Missouri, graduating from high school in 1963.

Mr. Ward received Bachelor of Science degree in Engineering Management from the University of Missouri-Rolla in 1969 and is currently working on a Master's Degree in Business Administration at Drury College, Springfield, Missouri, and expected to receive this degree in August 1979.

After receiving his undergraduate degree, Mr. Ward was employed by General Steel Industries-Castings Division in Granite City, Illinois. While at General Steel, he served as a Management Trainee and Production Control Analyst.

He began his railroad career in 1972, when he joined the St. Louis-San Francisco Railway Company as an Assistant Engineer Motive Power.

Mr. Ward is married to the former Jean Duggan, and they have two daughters.

He has been a member of LMOA since 1972.

Material Management:
Dollars Saved Through Efficiency

I. Investment and cost of carrying inventory—1979 (A comparison with the committee's 1973 study)

II. Dollars saved with Advanced Inventory Control systems, through increased availability

III. Material Distribution System —new Conrail system

IV. Warranty—a further look

Inflation, with its devestating impact on the locomotive maintenance dollar, has caused each railroad in the country to carefully look at its locomotive maintenance practices in order to determine where costs can be cut, or at least be kept at a stable level. Material management—the one area where much can be done to control costs—thus is taking on an increasingly important role in the area of locomotive maintenance.

Part I illustrates how material costs have increased over the past six years. Parts II through IV offer specific suggestions on where material dollars can be saved through efficient material management.

I

This committee report updates a 1973 report titled, "**Investment and Cost of Carrying Inventory.**" Current inventory investment and carrying costs are compared with those in 1973 to show what has occurred in this area since then.

Since 1973, much has happened to the railroad industry, especially in the locomotive maintenance area. Inflation takes a larger bite of the locomotive maintenance dollar each year. Seemingly constant material shortages make both the locomotive maintenance officer and the material management officer a new breed of "super planners."

To help determine the current dollar investment in locomotive maintenance material, the committee sent a questionnaire to Chief Mechanical Officers and top purchasing officers of 42 Class-1 line haul and switching and terminal railroads. We asked for specific facts about their locomotive fleets and inventories and the cost to carry those inventories. We also asked for opinions as to what direction each railroad's dollar investment is heading, whether rising, remaining stable, or decreasing. Finally, we asked each railroad for its 1973 and 1979 dollar investment in specific parts, such as cylinder heads and liners, pistons, rods, radiators and wheels and axles.

Twenty-one railroads replied, supplying at least part of the information requested. As in 1973, we decided that to total and average all data as submitted would be meaningless. Each railroad is unique in its locomotive maintenance operation and its diesel material inventory control structure, making it very difficult to compare one railroad with another. Thus, for purposes of an accurate comparison with the 1973 study, the committee grouped results in the following categories of fleet size: less than 50 locomotives, 51 to 250 locomotives, 251 to 1,200 locomotives, and railroads with fleets in excess of 1,200 locomotives.

Again, as in the 1973 study, we note that many railroads carry larger, more costly components in a capital account, separate from inventory. This accounts for a considerable variance in the reported figures. In addition, some railroads included operating supplies in some inventory investment figures, while other railroads did not. Whenever possible, investment figures were adjusted with respect to both amounts included in capital accounts and dollar value of operating supplies, in order to maintain a degree of consistency in the final figures reported.

Results of the 1979 survey, along with data reported in 1973, are as follows:

Reporting Railroads with Fleets of Less Than 50 Locomotives

The average inventory investment was $3.28 per horsepower and $5,193 per locomotive. This compares to a figure of $2.12 per horsepower and $2,972 per locomotive in 1973. This is a 54.7 percent increase in investment per horsepower and a 74.7 percent increase in investment per locomotive over 1973.

Reporting Railroads with Fleets From 51 to 250 Locomotives

The average inventory investment was $2.63 per horsepower and $4,997 per locomotive. This compares to a figure of $1.54 per horsepower and $2,778 per locomotive in 1973. This is a 70.8 percent increase in investment per horsepower and a 79.9 percent increase per locomotive in 1973.

Reporting Railroads with Fleets From 251 to 1,200 Locomotives

The average inventory investment was $2.43 per horsepower and $4,991 per locomotive. This compares to a figure of $1.24 per

horsepower and $2,161 per locomotive in 1973. This is a 96.0 percent increase in investment per horsepower and a 131.0 percent increase in investment per locomotive over 1973.

Reporting Railroads with Fleets In Excess of 1,200 Locomotives

The average inventory investment was $2.78 per horsepower and $6,114 per locomotive. This compares to a figure of $.95 per horsepower and $1,994 per locomotive in 1973. This is a 192.6 percent increase in investment per horsepower and a 214.5 percent increase in investment per locomotive over 1973.

Results of the 1973 study appeared to indicate that smaller railroads for the most part were carrying the larger inventories per horsepower and per locomotive, whereas larger railroads seemed to maintain their power with less money tied up in both inventory per horsepower and inventory per locomotive. This year's study did not indicate such a trend. This year's results indicate that the group of railroads with the largest number of locomotives also have the highest dollar investment in inventory, both per horsepower and per locomotive. And the group of railroads with the smallest number of locomotives rank second in this year's study. This trend did seem to hold true, however, in the two middle groups of railroads with medium size fleets.

To try to explain the drastic increase in inventory investment over 1973 would have required obtaining a large amount of very specific and detailed information from responding railroads. The committee believes, however, that it can safely conclude that inflation has been a major contributor to the drastic increase in inventory investment since 1973. Supporting that conclusion is a list of randomly selected EMD parts, with their price in the June 1, 1973, and October 1, 1978, price books:

EMD PART NO.	DESCRIPTION	PRICE 6-1-73	PRICE 10-1-78	PERCENT INCREASE
8157990	Liner	$196.37	$ 668.00	240
8074553	Piston	96.84	226.76	134
8419089	Piston	103.46	205.00	98
8459702	Piston	84.46	195.00	131
8057043	Hose	31.52	64.01	103
8340775	Switch	17.53	27.56	57
8424295	Switch	47.51	93.13	96
8404532	Relay	42.97	64.94	51
8177315	Gauge	29.66	44.89	51
8368469	Diode	67.78	69.86	3
8367607	Water Pump	251.27	592.66	136
8467560	Power Pack	873.21	1,864.52	114
8467562	Power Pack	771.44	1,637.52	112

Although the above represents increases by only one supplier, further investigation would no doubt reveal that all locomotive maintenance parts suppliers have had similar price increases. With such price increases, it is easy to see why inventory investment by the railroads has increased so dramatically over the past six years.

It was the opinion of the majority that an average figure of 16 percent annually for the cost of carrying inventory was valid for their locomotive inventories. This compares to a 22 percent figure in 1973 and reflects a significant improvement in this area.

Seventy-eight percent of those railroads reporting felt that their inventory investments were increasing. Seventeen percent felt that their inventory investments were stable, despite steadily rising prices, and five percent felt their investments were decreasing.

As a final part of this year's questionnaire, the committee asked the railroads for their 1973 and 1979 dollar investment in certain specific component parts. For the most part, such information was unavailable from most railroads. The committee was fortunate, in getting such investment figures from four railroads. That information is presented in Exhibit A.

We have tried to present the facts with regard to inventory investment in locomotive maintenance material. As in 1973, we were again unable to arrive at as many definite conclusions as we would have liked. However, one fact continues to stand out: Comprehensive planning in the area of material management remains a top priority for both the locomotive maintenance officer and the material management officer.

EXHIBIT A

COMPARISON OF DOLLAR INVESTMENT IN COMPONENT PARTS 1973 VS. 1978

	Cylinder Heads	
RR	1973	1978
A	$ 100	15,100
B	263,000	304,000
C	95,000	260,000
D	598,000	311,910

	Cylinder Liners		Pistons	
RR	1973	1978	1973	1978
A	$ 0	11,400	3,900	24,500
B	102,000	274,000	50,000	189,000
C	70,000	190,000	48,000	130,000
D	439,248	515,030	457,921	215,770

	Connecting Rods		Radiators	
RR	1973	1978	1973	1978
A	$ 300	3,000	—	—
B	59,000	66,000	94,000	273,000
C	32,000	85,000	24,000	65,000
D	36,692	77,700	264,730	297,870

	Loco Wheels		Loco Axles	
RR	1973	1978	1973	1978
A	$ 28,200	79,700	—	—
B	264,000	417,000	170,000	156,000
C	295,000	535,000	340,000	600,000
D	637,973	606,830	19,368	38,220

II

DOLLARS SAVED THROUGH ADVANCED INVENTORY CONTROL SYSTEMS VIA INCREASED AVAILABILITY

As inflation continues to spiral upward, the need for an effective and efficient inventory control system is increasingly important. Material cost increases have raised the dollar value of inventory, while new locomotive products and developments have increased the number of items required. Only an efficient management system can

balance budgetary constraints with availability requirements.

Maintenance officers are often caught in the supply and demand cycle. In reality, only a portion of the numerous locomotive parts can be maintained in inventory. Yet, if non-availability results in locomotive out of service, potential revenue generation, which supports the cost of inventory, is lost. The ability to forecast needs and peak demands becomes crucial. Inability to do so will result in an inventory system that is cumbersome or cost prohibitive.

As the problem becames more complex, use of a computer control system and data base becomes essential. The Missouri Pacific reached this crossroad in 1965, when the cost/benefit ratio of centralization and computerization became evident. Here is a brief description of MoPac's inventory control system along with its benefits.

Over 31,000 separate items are stocked at MoPac's North Little Rock, Arkansas, Matrial Distribution Center and nine material warehouse locations, which protect local Mechanical Department operations. An inventory of approximately $29 million, with $3.5 million dedicated to diesel repair material, indicates the monetary needs, requirements and importance. The Material Distribution Center, located centrally by geography and system operation, is responsible for fulfilling the requirements of all on-line locations on a scheduled basis.

Each of the 31,000 items is assigned a unique stock number consisting of a two-digit unit measure, three-digit class number, and seven-digit control number. In many cases, the vendor part number is incorporated into the control number, further simplifying cross-referencing. An additional suffix number identifies new, shop built/shop repaired and vendor repaired items.

Economic order quantity or EOQ formulas, which consider price, lead time and usage, are utilized in the inventory control system. Four reorder cycles per year was determined to be the most cost effective interval, with the exception of low cost/low usage items. Those items are purchased in six-month quantities, which also reduces the possibility of non-availability.

Reorder point and reorder quantity levels are established by considering usage and lead time for each item. Those factors are updated continually to maintain current reorder point/reorder quantity levels, which is absolutely essential to respond to the needs of the using department.

Usage, which is based on the current twelve-month item issue, indicates upward or downward trends. However, a sharp fluctuation is moderated by the smoothing effect of adding current month usage to eleven months of normal usage. Although necessary in computing average item requirements and inventory levels, this method is often criticized for the inability

to react to immediate changes in needs or seasonal usage. To overcome the detrimental effect of averaging, manual overrides allow stocking items in advance when the requirements are known. Also, safety stock is maintained for critical and seasonal items, based on past experience and feedback from the using departments.

When programs or modifications that affect normal stock material use are planned, the reorder point and reorder quantity are adjusted to compensate for the additional usage. This adjustment is based on the bill of material submitted by the using department.

To better illustrate the inventory control system, an example of the complete process is presented. The using department initiates the process by completing a requisition for required store stock material. This requisition, which identifies items by stock number, description, and quantity, is forwarded through the approval chain and then to the Material Distribution Center. Upon receipt at the Center, each item and quantity is transmitted and stored in the computer until shipment is scheduled for that point. Material shipping schedules have been established for each point based on its material usage. At time of shipment, material ordered on all outstanding requisitions is retrieved from the computer in two forms. A picking list is provided for use by the material handler, indicating total quantities for each item to fill the order. This eliminates manually summing of identical items on separate requisitions or duplicate trips to the storage area.

A shipping document also is printed that lists the consignee, shipping instructions, stock number, item description, quantity ordered, quantity shipped, item expenditure, and total cost of material in that car shipment. Backorders are also listed, indicating quantities owed to that point, and maintained in computer storage for shipping when the inventory is replenished. When the shipping document is received at the point, they have a complete balance sheet of all transactions with the material warehouse. The procedure of reordering material not shipped, and the subsequent shipment of a greater quantity than required, is eliminated.

Coinciding with this process, inventory levels are compared with reorder point levels once a week through the use of an IBM 370-168 computer. To prevent the false comparing of inventory levels only, the quantity already on order from the vendor is added and the quantity that is on order by the using departments, quantity required for programs, and safety stock is subtracted. This resultant figure is compared with the reorder point to determine the need to purchase. If below the reorder point, a program is run, containing vendor name and address, current price, reorder quantity, and shipping instructions. A sufficient number of

predetermined reorder quantities, plus one lead time quantity, is ordered until the inventory is brought above the reorder point level. The computer output is a completed purchase order on a standard form that requires only the purchasing agent's signature.

This description of MoPac's inventory control system covers the basics only and does not include the many enhancements and capabilities which are constantly being added. However, the system is only a means to an end; we will now discuss the end result. The determination of the improvement in material availability and savings realized through an advanced inventory control system can best be made by answering several basic questions.

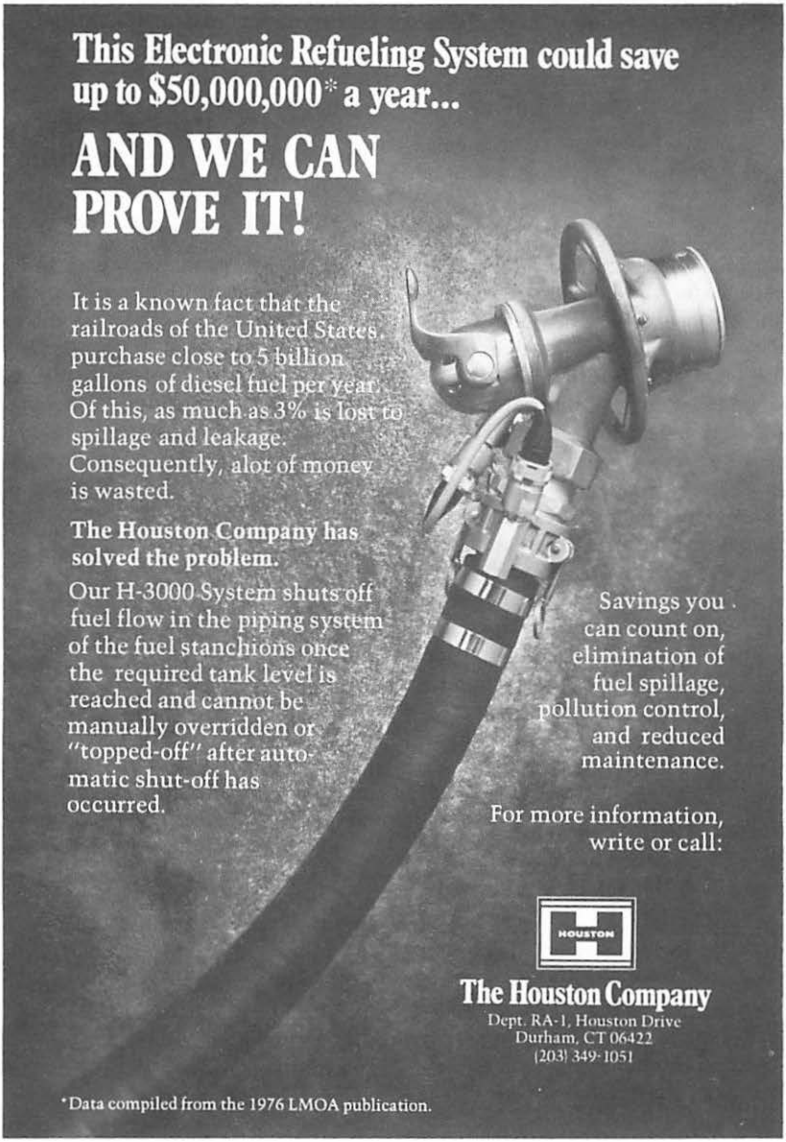
Has the use of the computer eliminated non-availability of material and the resultant effect on the maintenance operation? Although the computer certainly provides a valuable means to eliminate stockouts, material non-availability still occurs. The question becomes whether railroads can afford to completely eliminate stockouts, not their capability to prevent stockouts. However, critical items that can result in locomotive out of service must be given a high priority in computing safety stock and reorder quantity levels.

Non-availability of material should occur only at the time of inventory replenishment, since the computer has already sensed the need to reorder and the reorder cycle has begun. This is the real test of predetermined lead times, reorder point levels, and safety stock levels. If these levels are insufficient, outages will occur and the maintenance effort will be affected. Also, the system now depends on the ability of the vendor to respond within the lead time period allotted.

Has the computer produced a monetary savings as predicted? The answer is a definite "Yes". The initial savings produced by computer utilization and centralization was within the Material Department. The consolidation of material warehouses allowed the system to be operated with less manpower and at lower inventory levels, with a resultant savings. The automatic ordering and generation of purchase orders has eliminated the manual requirements and has resulted in a real-time inventory control system.

The savings produced in the Mechanical Department is harder to determine. A 1977 paper presented by this committee proposed a locomotive availability goal of 95 percent. To obtain this goal, units held for material could not exceed 0.5 percent of the fleet. Without an efficient inventory control system, this goal becomes unattainable and the cost of out-of-service locomotives becomes an operating liability.

Most railroads have a cost figure they use to determine the loss due to an out-of-service locomotive, which provides an indicator of cost


This Electronic Refueling System could save up to $50,000,000* a year...
AND WE CAN PROVE IT!
It is a known fact that the railroads of the United States purchase close to 5 billion gallons of diesel fuel per year. Of this, as much as 3% is lost to spillage and leakage. Consequently, alot of money is wasted.
The Houston Company has solved the problem.
Our H-3000 System shuts off fuel flow in the piping system of the fuel stanchions once the required tank level is reached and cannot be manually overridden or "topped-off" after automatic shut-off has occurred.
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*Data compiled from the 1976 LMOA publication.

effectiveness of the inventory control system. To prevent distortion by using percentages only, the cost and effect of robbing material to improve locomotive availability must be considered and this is a topic of a later presentation.

What are the benefits of a computer-oriented inventory control system?

In addition to the previously mentioned benefits, the information available in the computer provides valuable assistance in budget control. Each Master Mechanic receives a daily printout of cost of material issued to points under his jurisdiction during the previous day. They can easily monitor expenses and take corrective action to prevent budget overruns. At the end of each month, a computer-generated report lists transactions for the entire month, including item descriptions, quantities, and item cost for each budget code. This is valuable in determining major expense items and for formulating budgets for subsequent years.

The primary benefit is that information is furnished on a real-time basis allowing preventive measures to be taken immediately.

In summary, volume of material and cost of inventory makes an advanced inventory control system necessary for managing warehousing, distribution and ordering. The computer provides the tool to fulfill these requirements. The effect on material availability and the savings realized are dependent on the degree of implementation of the system. Company policy will determine the balance between inventory cost and material availability and the priority given to each.

III
MATERIAL DISTRIBUTION SYSTEMS
NEW CONRAIL SYSTEM

The most economical and practical solution to the many interrelated defects and problems in the present distribution system requires a general restructuring of warehousing and supply concepts, geographic locations, areas to be serviced, and organizational structure.

Geographically, the new Conrail system is divided into three sectors. A Distribution Center is located as centrally as possible to the warehouse in each sector and supplies all commodities (M/E, M/W and general) used within its assigned area (see Exhibit A).

The management organization is simplified. All material planning and replenishment activities were moved from individual distribution centers and centralized into an Inventory Control Point (ICP) The ICP is co-located with the distribution system headquarters in Philadelphia, next to purchasing, and reports directly to the distribution system manager. The distribution system manager also has on his staff personnel with transportation and facility expertise (see Exhibit B)

Distribution Centers

The eastern, central and western sectors are supported by an eastern, central and western Distribution Center. Each center warehouses and supplies materials normally distributed through the distribution system and used in that sector. The organization and operating procedures of the three centers are uniform, the personnel contingent at each ranging from 50 to 60.

Eastern Sector

The eastern Distribution Center is located in Reading PA and includes the geographic area from Boston, south to Baltimore, west to Harrisburg PA, north to Utica NY and back to Boston. Regionally, this Distribution Center provides service to the Eastern, New York, Atlantic regions, and half of the Northeast region.

This area represents one-quarter of Conrail's geographic area and roughly a third of the operational activity.

There are 84 car, 52 locomotive, and 131 M/W consignees, plus stations, towers, and railroad property. Appropriately, Reading's location is near the center of the eastern sector and has excellent accessibility by both rail and road.

The structure is a three-story, brick-walled, flat-roofed building, with excellent rail loading and unloading facilities. Two additional buildings are located on adjacent platforms, adding significantly to the protected storage areas of the complex. Each platform dock is covered, providing for the storage of volume outside materials. Certain docks and ground support areas have heavy-duty overhead cranes that enhance the ability to handle heavy M/W materials efficiently. Reading's proximity to good sources of supply provides additional benefits of lower inbound transportation costs.

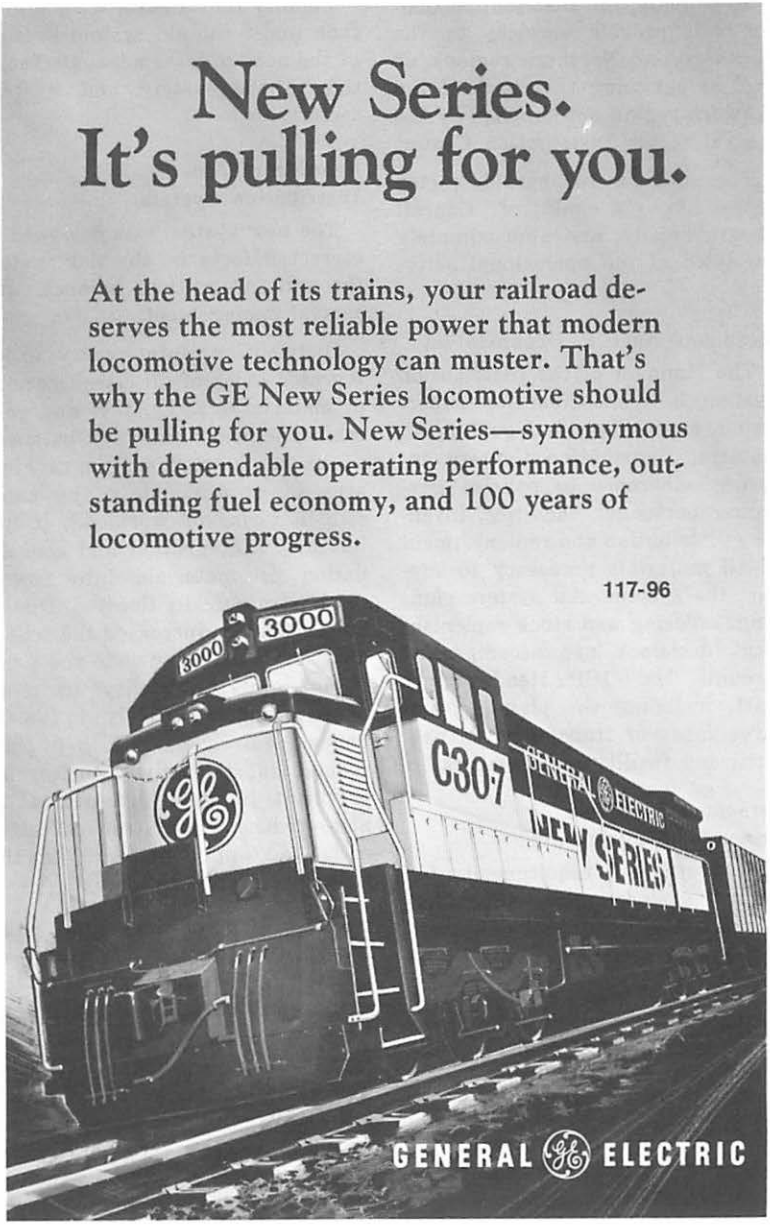
Central Sector

The central Distribution Center is located in south Altoona PA. It includes the geographic area bounded on the east by the eastern sector (Harrisburgh PA to Utica NY), west to Canton OH, north to Cleveland OH, and then east to Utica. Regionally, the Distribution Center provides service to the Central region, one-half of the Northeast region, and a portion of the Western region. This area represents one-quarter of Conrail's geographic area and again roughly one-third of the operation's activity. South Altoona's central location in the central sector and its accessibility to the facilities makes it well suited for its new role.

Western Sector

The site for the location of the western sector Distribution Center has not as yet been selected. The sector is intended to consolidate the distribution activities from Beech Grove IN and Columbus OH.

Geographically, the western sector will include everything west of Cleveland OH and east of Detroit MI to the railroad terminals in West Virginia.


New Series.
It's pulling for you.
At the head of its trains, your railroad deserves the most reliable power that modern locomotive technology can muster. That's why the GE New Series locomotive should be pulling for you. New Series—synonymous with dependable operating performance, outstanding fuel economy, and 100 years of locomotive progress.
117-96
3000
C30-7
GENERAL ELECTRIC

Regionally, the Distribution Center will provide services to the Southern and Northern regions, as well as servicing that part of the Western region not supplied by the central sector Distribution Center.

The area covered by this sector represents one-half of Conrail geographically, and approximately one-third of the operational activity.

Headquarters/ICP Organization

The Manager of the Distribution System is responsible for supervising, controlling, and guiding all material Distribution Centers, insuring adherence to policies governing personnel, facilities, inventory distribution and replenishment of all materials necessary to support the system. All system planning, ordering and stock replenishment decisions are accomplished through the ICP / Headquarters staff, including the planning and surveillance of transportation patterns and facility requirements.

Personnel and Other Resource Requirements

The personnel requirements for the new system approximated that of the old system, 197 agreement and non-agreement personnel.

Manning of the new eastern Distribution Center within the present personnel level was made possible by the consolidation of Distribution Centers in the western sector.

Equipment requirements remained at the same levels as under the old system.

Facility rental costs were higher than under the old system because of the need to lease adequate facilities in the eastern and western sectors.

Benefits of New Distribution System

The new system was designed to correct defects in the old system through integration, balance, and central management.

Distribution centers carry an integrated stock of all classifications of material — M/E, M/W and general. The workloads are balanced so as to support a geographical area of approximately the same size in terms of workload, if not territory. Integration and consolidation of materials into fewer, more strategically located Distribution Centers increased the scheduled service frequency to the user. It brought the ability to react quickly and effectively to emergency requirements, which in turn reduces substantially inventory investment in field inventories. It also reduced the transportation costs to supply material to the field inventory locations.

In addition, it enabled the distribution system to shorten lead time and it reduced appreciably the need to make local procurements at field maintenance locations. The system allows a substantial reduction in the number of purchase orders, receipt documents, and vendor invoices that were being processed throughout the railroad. The general reduction in paper

flow affords a better control, discipline and error rate — in all, a more reliable record upon which to base inventory management decisions.

Positive management controls are afforded by the central distribution system, with fixed responsibility for inventory investment. The responsibility for improved planning of transportation and facility requirements is also fixed and accommodated.

Placing the Inventory Control Point in Philadelphia established a strong central control for all planning, ordering, and stock replenishment decisions for inventories in the distribution system. Fewer stock procurements are necessary, and they are based on better intelligence of usage patterns throughout the entire railroad. Visibility of system-wide usage patterns is obtainable not only in the distribution system, but field maintenance systems as well.

Expediting material from vendors is greatly facilitated. With the ICP, Conrail is able to improve substantially the availability of material in the distribution system at any desired investment level over the former system. The ICP is able to assist in reducing and maintaining more appropriate levels of inventory in the field maintenance system.

The ICP also is able to survey stock levels in field maintenance terminals with a view toward reclaiming excess material to satisfy distribution system requirements.

Transportation

Delivery of materials used to maintain equipment for operations is made with a network for truck and van deliveries (see Exhibit C). There are 150 truck runs weekly. The schedule enables distribution centers to have an even flow of parts at given intervals throughout the system. In most instances operations are Monday through Saturday, with the option of truck service for emergencies that may occur on Sundays or holidays. Supplies that are scheduled for satellite terminals throughout the system are delivered in bulk to seven major terminals for distribution within the regions by trucks assigned to various store locations.

Transportation costs are not currently fully allocated. Here is a brief tracking of major components for the last three years:

1977 Shipped 139.7 (000) —
Cost of Transportation —
2.2 ($Mil)

1978 Shipped 126.8 (000) —
Cost of transportation —
4.1 ($Mil)

1979 Shipped ? —
Cost of transportation —
Projected — 4.6 ($Mil)

Conrail plans to reduce the number of truck trips by eleven per week, with a cash savings of $185,900 — 11 @ $325 x 52 = $185,900.

Plans for reducing truck driver overtime awaiting items to be delivered from back shops will save $19,890 — 15 Hrs/Wk @ 25.50 x 52 = $19,890.

Proposed Distribution Centers

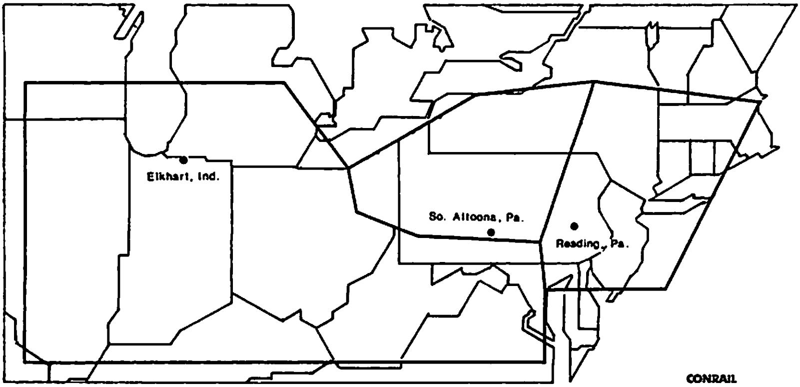


EXHIBIT A

Table of Organization for Staff

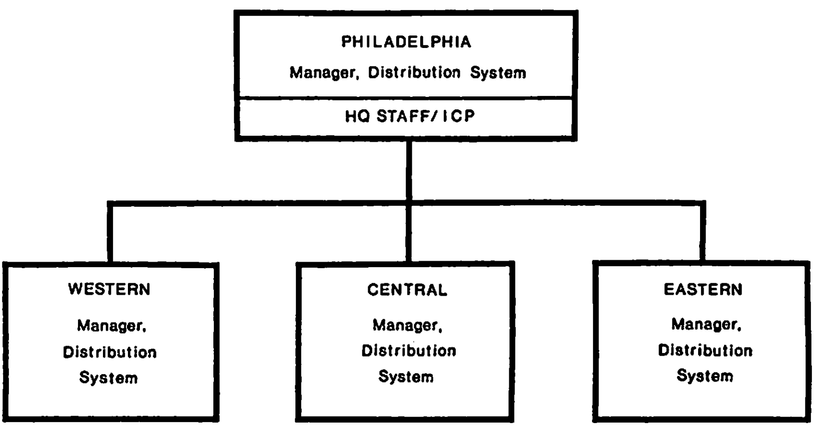


EXHIBIT B

Schedule for Truck and Van Deliveries

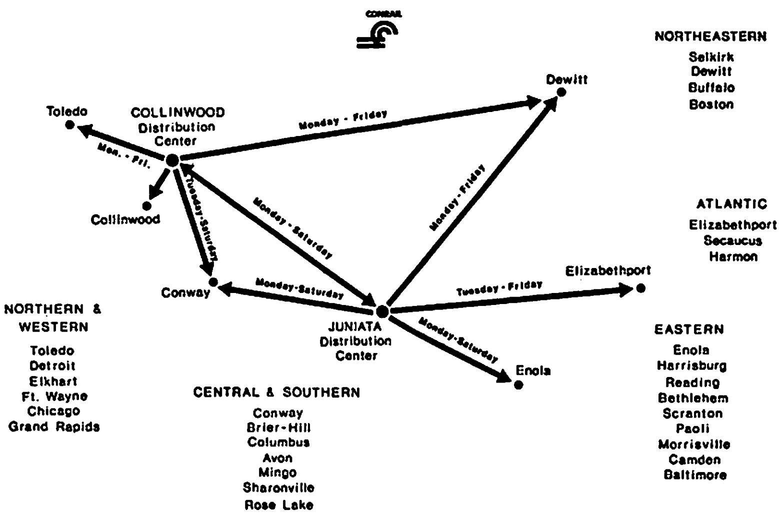


EXHIBIT C

Those plans will be accomplished by enhancing the efficiency at the back shop under a new R&R system presently being implemented between material management and rehabilitation planning and control — mechanical.

IV
WARRANTY — A FURTHER LOOK

The Cost and Monetary Benefits Of Controlling Warranty

The cost and monetary benefits of controlling warranty for any individual railroad can only be determined by that railroad.

Locomotive maintenance officers must remember that the money manufacturers use for warranty purposes is built into the price of the item. The customer, therefore, pays for warranty protection. It is our responsibility on an economic basis to identify and control material covered under the vendor warranty, and claim a warranty adjustment upon failure of that part.

The following is EMD's position regarding the cost and monetary benefits of controlling warranty:

As a manufacturer, we desire to keep our warranty expense as low as possible yet honor each and every warranty claim received. A reduction in warranty expense can and would eventually reflect a reduction in the pricing structure of material. We do not solicit warranty. We do, however, have our regional service offices staffed by numerous district engineers who call upon our customers for many reasons, one of which is to handle warranty claims. They can only be as effective in handling a claim for you as you are effective in your control of material under warranty.

We hope that in all cases each of our customers, whether railroad, marine or industrial power users, know of and understand our warranty provisions. We have written and published "Warranty Handbooks" for our customers. These books were updated and distributed in late 1978. They are meant to assist you, our customers, in being aware of the criteria required for claiming warranty on failed material. It is not a complicated system. The EDM District Engineers are well versed on warranty, and with their help a warranty claim is simple to request.

The departments and/or personnel on your properties assigned to handle warranty should become as knowledgeable as possible concerning all aspects of warranty handling with EMD as well as your other vendors.

We who work in the EMD warranty area are in a position to see mishandling of warranty claims on a daily basis. The mishandling could be due to lack of knowledge on the part of our District Engineers and/or on the part of our customers. We prefer to believe our District Engineers are competent in every respect to warranty handling and process warranty claims as requested by the customer.

We see warranty claims for items with a value far less than the paperwork involved for both the customer and EMD.

We see warranty claims for items both the customer and the District Engineer know will be rejected; however, written due to customers' insistence.

We see warranty claims for materials that have not even failed.

We see warranty claims for material that when eventually located was improperly and/or not even identified with a warranty claim.

We see warranty claims for material that is never returned to EMD for processing.

We see warranty claims for material with insufficient information apparently available to the District Engineer to justify writing the warranty claim, let alone our accepting the claim.

Such claims are a needless expense for the manufacturer as well as the customer.

The average repair of an AR10 alternator is about $4,500.

The average repair of a turbocharger is about $5,000.

The average repair of a power pack is about $600.

The average repair of an injector is about $150.

The average repair of small miscellaneous electrical components is about $75.

We see numerous items returned to EMD for "Repair and Return" or "UTEX" handling that, after inspection is made, would qualify for warranty; yet a warranty request was never made.

In many of these cases, the information is passed on to our regional service offices for investigation, and if a warranty claim is justified, the item is handled on warranty. The above figures are averages only and are used here to bring your attention to added possible costs of operating EMD equipment when warranty is overlooked.

Another area deserving your attention that should be controlled as closely as possible is the practice of removing non-failed material from a locomotive under warranty and applying the item to another unit whether in or out of warranty.

The basis for the two-year/250,000-mile warranty on new or line rebuild locomotives is that all components are factory assembled under conditions controlled by EMD, with proper fits, to provide a maximum service life. Removal of a component from the original locomotive and applied by the customer to another locomotive changes all this, and the customer becomes responsible for the installation of the component. In general, components removed from a locomotive during warranty period and reapplied elsewhere revert to the one-year/100,000-mile warranty on the basis of the environmental change.

The greatest problem in warranty interpretation on transferral of components from one unit to another involves traction motors.

As specified above, EMD warrants a new locomotive for two years or 250,000 miles, whichever shall first occur. Therefore, to insure the warranty provided to the customer, it is necessary that the replacement item applied to the original equipment be either "UTEX" or a new item purchased from EMD. The item applied as "UTEX" or "New" though having only one year or 100,000-mile warranty provision will earn out the unexpired unit warranty, thus assuring a two-year warranty unit.

EMD warranty specifies "Repair or Replace at Our Option."

As you are all aware, EMD carries approximately 400 to 500 items in the "UTEX" pool. These items include engines, generators, traction motors, engine and electrical components.

The options available on warranty failures are:

"UTEX"
REPAIR AND RETURN, OR
SCRAP FOR CREDIT

There are naturally certain rules that must be adhered to in connection with the options. For instance, failure of a traction motor would be handled "UTEX" or "Repair and Return," not for credit. A small engine component not on "UTEX" would be handled "Repair and Return" or credit. Therefore, watch for and request the option most beneficial to you.

For example: If an original equipment governor failed after 13 months of service and is removed from the unit for warranty handling, remember: you have an option of "Repair and Return" or "UTEX." If handled repair and return, the governor will be handled repair and return. However, remember this item when removed reverts to one-year/100,000-mile warranty. Therefore, when returned, there would be no warranty remaining. If it had failed after six months of service, it would have six months of warranty remaining.

If handled on "UTEX," the replacement governor is covered by one year or 100,000 miles of warranty. Again, if it were EMD responsibility, in either case, a no-charge invoice would be issued.

Based on the above, you would insist on "UTEX" handling.

In addition, watch for disposition of failed material wherein the EMD District Engineer has authorized "Scrap on Customer's Property for Credit." We have processed AFA's as such, allowed credit and closed the transaction. A month or so later, the material that was to have been scrapped is at our receiving dock. You have paid for unnecessary freight charges, along with unnecessary paperwork for both yourself and EMD. In addition, if the claim were for a half-dozen cylinder heads, you have also lost scrap value.

It is premature to make any kind of appraisal of effectiveness of the metallic labels talked about in our previous meetings. However, we believe they would help substantially in identifying warranty material. A computer system, such as previously covered by this committee and as used on the SL-SF Railroad, and probably others, is also a very effective method of such control.

A recent survey of our records indicates an approximate 12 percent rejection of warranty claims. To reject a warranty claim, we must have good, clear evidence documented by the inspection report indicating customer responsibility. Anything less is accepted by EMD. The above then indicates that due to improper application, improper maintenance, improper storage, improper use of those items, you have lost revenue. You will receive an invoice covering the repair charges that would normally be accepted by the warranty account. In the case of turbochargers, traction motors and generators, this can be expensive.

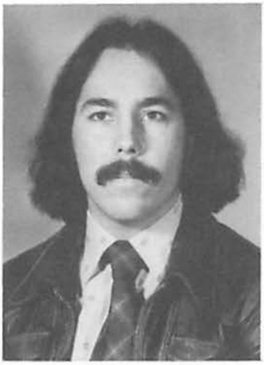
From our position, the costs versus the monetary benefits of controlling warranty is difficult to determine. The cost would depend upon the practice and procedure of the individual customer. We believe that the first and most important step toward warranty handling is to make sure you have a person or persons as familiar as possible with your vendor warranty and procedure for handling warranty. By doing so, you are in a much better position to realize the monetary benefits of controlling warranty.

Monday, September 17, 1979

3:30 P.M.

REPORT OF THE COMMITTEE ON NEW DEVELOPMENTS

Pre-Convention Presentation: Southwestern Railway Club



April 26, 1979
Camelot Inn
Little Rock, AR

C. W. COX, Chairman
Assistant Roundhouse Foreman
The Atchison, Topeka & Santa Fe
Railway Company
22nd and Argentine Boulevard
Kansas City, KS 66106

VICE CHAIRMAN

J. J. Boline, Manager Information Systems, Illinois Central Gulf Railroad Co., 233 North Michigan Avenue, Chicago, IL 60601

COMMITTEE MEMBERS

G. R. Abernathy, Chief Mechanical Officer, Delaware & Hudson Railway Co., Watervliet, NY 12189

R. M. Campbell, Diesel Supervisor, Belt Railway Company of Chicago, Chicago, IL 60638

R. E. Carter, Engineer, Southern Pacific Transporation Co., San Francisco, CA 94105

M. A. Coles, Diesel Supervisor, Missouri Pacific Railroad Co., North Little Rock, AR 72114

D. G. Goehring, Manager Maintenance Planning, Amtrak, Washington, DC 20001

M. E. Kane, Manager-Locomotive Information Systems, Consolidated Rail Corp., Philadelphia, PA 19104

Walter Weck, Assistant General Service Manager, Electro-Motive Division, LaGrange, IL 60525

T. C. Whittle, Manager Product Planning, Locomotive Products Dept., General Electric Co., Erie, PA 16501

ADVISORY MEMBER

Marilynne E. Jacobs, Research Manager, Federal Administration/RRD-12, Washington, DC 20590

1979 TOPIC:
"NEW DEVELOPMENTS FOR BETTER MAINTENANCE"

PERSONAL HISTORY

CHRIS W. COX

Born in San Bernardino California on Christmas day, 1947; thus the name Chris.

Began employment with the Santa Fe in June 1970 working as a machinist apprentice during summer vacations.

Upon graduation from San Diego State University, with a B.S. degree in Mechanical Engineering in February 1972 he entered a Management Training Program offered by the Santa Fe. On completion of the nine month program he was appointed to an assistant position in Santa Fe's Industrial Engineering Department at Kansas City Shop, and in July 1973 to Barstow Shop.

In December 1974 he was promoted to Locomotive Maintenance Supervisor for the system with headquarters in Chicago. In April 1978 he was moved to Kansas City to the position of Locomotive Gang Foreman.

Special interests are: antiques, woodworking, sports cars and many other crafts, including rebuilding antique guitars and antique furniture.

"NEW DEVELOPMENTS FOR BETTER MAINTENANCE"

The concept of "New Developments" is of course relative to time; the classic Model "T" Ford was a new development in 1923, but today is considered an antique. In this same respect, this committee has the task each year of selecting subjects for a paper which will not be outdated a year later. Subjects that will be meaningful and new to all concerned. Even in view of the rapid rate of change of today's locomotive and its environment, we believe we have accomplished our goal.

I

Applying Minicomputer and Microprocessor Technology to Locomotive Diagnostics.

In this section of the paper we describe the various systems in use and systems still under development.

II

A True Cold Weather Locomotive — Current Production and Future Goals.

The subject of a "True Cold Weather Locomotive" has been in the spotlight due to recent harsh winters. We have included this subject in this year's paper to maintain an awareness of current development for improvement of locomotive cold weather operation.

III

Quality Control Departments and Their Effect on Maintenance Programs.

Many railroads have been directing their attention towards the construction of Quality Control departments. We will take a close look at these departments and discuss their impact on maintenance programs.

IV

The Training of Locomotive Maintenance Personnel to Improve Maintenance Programs.

The tremendous need for the training of locomotive maintenance personnel both apprentices and journeymen will be restated in view of today's demands for better maintenance.

V

New Developments and Concepts in Locomotive Design.

In this portion of our paper we will discuss briefly: (A) Automatic Speed Control Devices, (B) GE's New Turbocharger, (C) The Testing and Performance of the New Model Locomotives.

It is our intention to present all subjects in this paper in a manner that will allow one to decide if these new developments will actually allow for better maintenance. It is not always possible to draw hard and fast conclusions as to whether or not a new development will be a success or a failure. Many of these new developments must grow in order to reach maturity and success. Some of them will be tested and fail. It is the continuous effort and just plain hard work by the people in our industry that will decide the fate of each.

I. Applying Minicomputer and Microprocessor Technology to Locomotive Diagnostics

Solid state technology has rapidly exploded in the last five years with applications and costs to make it well within the grasp of both the lay person and the engineer. The compact size, reliability, and versatility of integrated circuit design, microprocessor chips, and magnetic core or bubble memories have opened up a vast array of potential applications, particularly in the areas of shop and onboard locomotive diagnostics.

The railroad industry is already aware of the advantages of the SEARCH unit for analyzing, debugging, and fine tuning electrical systems onboard the diesel locomotive in a shop environment. In the heavy duty diesel truck industry, two companies have developed similar diagnostic tools which not only evaluate electrical components and subassemblies but also monitor and diagnose major mechanical systems. The primary components of the Diesel Diagnostic System produced by Hamilton Test Systems and the Integrated Diesel Engine Analyzer (IDEA) produced by Harris Corporation (PRD) include:

- Minicomputer or microprocessor controller and memory with display
- Tape drive
- Line printer for hardcopy test report identifying faulty components
- One magnetic tape cassette per engine type containing control programs, test sequences, tests, and boundary test limits
- Hand held keyboard and display
- Sensor harness

Once the sensor harness is installed, out-of-bound conditions are easily pinpointed in the lubrication, air, electrical, brake, fuel, cooling and compression or power systems. The Diesel Diagnostic System with minicomputer is about the size of a desk. However, the microprocessor IDEA unit was designed for off-highway as well as shop applications and can be carried like a large suitcase. Another advantage of the IDEA unit is that each test report can be transferred through a digital peripheral device to an off-site computer for storage and analysis.

Diagnostic test equipment for use onboard the diesel locomotive is another story. In designing a minicomputer or microprocessor system for onboard diagnostics, it is necessary to know what critical parameters should be measured, why they should be measured, and what their operational boundary limits should be. To define what should be measured requires a knowledge of where the problems lie. At this time many railroads are just setting up computerized systems to evaluate motive power unit histories, warranty control, component part and individual unit failure rates, unit availability and equipment utilization. Such statistical data on motive power operations and performance should be maintained to measure the effectiveness of any motive power fleet, and to define where changes can be made to improve maintainability and reliability.

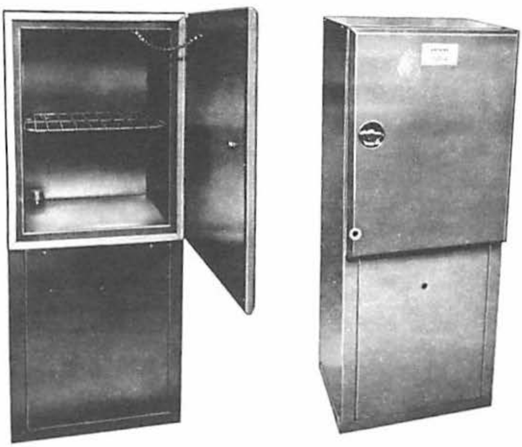
Because such detailed data bases are still being compiled and because requirements for a comprehensive onboard diagnostic system have not been specifically spelled out, a variety of onboard test equipment and monitoring devices have been developed in response to a particular need of the requesting organization. Some examples of these include the following:

1. **Tractive Effort Monitor:** As part of the Track/Train Dynamics Program, Pulse Electronics and the AAR combined efforts to produce a single meter indicating total tractive effort and dynamic braking force for an entire locomotive consist. Signals of voltage and current from one traction motor per locomotive are trainlined to the lead unit, multiplied together, summed for all the locomotives, and divided by the recorded operating speed. The meter values can be compared to a table of optimal values kept in the locomotive cab.

2. **Event Recorders:** The Pulse Electronic Railway Recorders and the Vapor Corporation Train Operation Recorder System (TOR) are both characterized as event recorders. On/off locomotive conditions such as brake applications, forward/reverse movements, throttle positions, stops and power braking as well as time, distance and speed are recorded on a continuous loop magnetic tape. Traction motor current is recorded as an option. Additional

BULLETIN VR250

VORTACOOL® VR250



Tops in Cab Refrigerator Reliability

Designed specifically for use in locomotive cabs, the new Vortacool VR250 is the ultimate in reliability and maintenance-free operation. The patented refrigerating unit has **no** moving parts, **no** refrigerant to leak, requires **no** electrical power, and is virtually impervious to shock and vibration. The Vortacool operates entirely on air supplied by the locomotive's compressor.

- Simple design keeps initial costs down, as well as maintenance.
- Meets AAR clean cab concept.
- Stainless steel storage compartment.
- Large capacity — full 2$\frac{1}{2}$ cubic feet.
- Front-opening compartment door for easy access to stacked items.
- Foam-insulated compartment and door.
- Rubber-gasketed door opening.
- Positive-locking door latch.
- Compact, with base 19$\frac{1}{4}$" x 14$\frac{3}{4}$", height 46".
- Fits standard AAR niche.
- 5-year limited warranty.
- Self-dumping filter cleans supply air.
- Standard color is custom green. Others available at additional cost.
- Shipping weight approximately 100 lbs.

Installation requirements:
- Standard $\frac{3}{8}$" pipe is used for supply air.
- Compressed air must be at main reservoir pressure (usually 140 psi) and obtained from the cleanest, coolest source available.

CTC CLEVELAND TECHNICAL CENTER, INC.

13600 Deise Avenue • Cleveland, Ohio 44110
Phone (216) 451-6455

options on the TOR system include sanding, wheel slip, horn and signal acknowledgement. Playback units are required to translate the magnetic tape into a strip chart record or into a computer-acceptable format. Various software packages can be provided for data reduction.

3. **Barco Locomotive Performance Verifier (Aeroquip Corp.):** This unit produces a strip chart recording of governor balance at eighth throttle position by measuring the position of the injector rack. Normal operation is indicated by a trace between two datum lines. Excursions to the left or right of these lines indicate low power for extended periods, overload, excessive governor hunting, excessive unloading, or intermittent low power. The ability to recognize the different signature patterns is required.

4. **Locomotive Data Acquisition Package (LDAP):** Being developed by the Lawrence Berkeley Laboratory for the Federal Railroad Administration as a research tool, this sophisticated minicomputer system is programmable and can record up to forty-eight channels of analog or digital information on magnetic tape. The basic set of performance parameters currently under development include: time, speed, air brake applications, drawbar force, traction motor current and voltage, dynamic brake current, turbocharger pressure, grade, throttle setting, reverser setting, slip-spin activation, fuel consumption, air temperature and engine temperature. A playback unit is required to translate the magnetic tape into a strip chart record or into a computer-acceptable format. Various software packages will be provided for data reduction. In the future, this system will be reconfigured for diagnostic evaluation of the power plant.

5. **Fuel and Power Output Recorders:** Both EMD and GE have produced systems to measure and record onboard locomotive fuel consumption. In addition the GE system is capable of recording total power output of the locomotive. CP Rail is currently considering an independent contractor's proposal to develop a digital display system using a microprocessor to serially record and store trainlined signals of fuel consumption and power output for a four unit locomotive consist. Many railroads are also designing their own fuel and power output sensors and recorders.

6. **Locomotive Onboard Monitoring System:** Harris Controls is currently testing an engineering prototype microprocessor system for onboard monitoring and diagnostic evaluation. This system monitors the behavior of electrical systems, engine operation through a load cell technique, air compressor per-

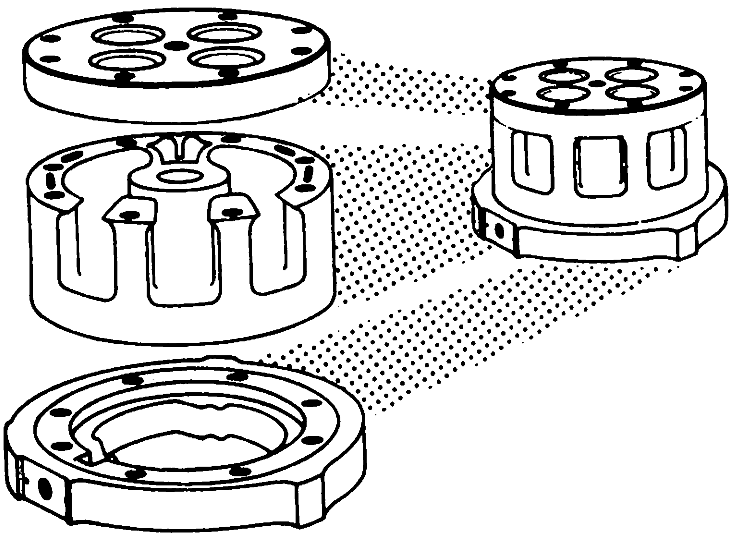
formance, and turbocharger performance. Horsepower output and fuel consumption are also recorded. As a diagnostic tool, it is capable of differentiating between an engine malfunction or an electrical problem. Data are not recorded on magnetic tape but are directly transmitted though a digital peripheral device to an off-site computer. Various software packages will be provided for data reduction. An annunciator or fault light panel is used to indicate a failed condition.

As a sign of the future, the Boeing Vertol Company has also recommended in Volume One of their report entitled "Locomotive Cab Design Development" (DOT-TSC-FRA-76-22-1) that the annunciator or fault light technique be used to represent onboard diesel diagnostics. A panel of 21 annunciators was suggested which would be combined with a cathode ray tube (CRT) display of grades, curves, brake pipe gradient and buff-draft forces for the ultimate in train handling.

In the rail passenger industry, the annunciator panel technique has been used for several years to enhance onboard diagnostics. A good example of the innovative research accomplished in this area involved the upgrading of the self-propelled electric Metroliner car to improve availability and maintainability. As a test case, four Metroliner cars underwent extensive design improvements to meet the requirement of the Department of Transportation that 80% of all problems be diagnosed and repaired within the one hour turnaround time at the Washington and New York terminals. The onboard diagnostics included a panel of six lights activated by fault signals trainlined from the trailing cars and a local car monitoring panel. Both panels home in on faults in the propulsion and braking systems. The local car monitoring panel includes six rows of lights and two rows of meters. The first row of lights indicates main fault and the remaining lights and meters locate the specific area of the fault. When a fault occurs the lights remain on until reset.

The main disadvantage of the fault light panel is that no means has been provided for automatically recording fault conditions for use by the maintenance facility. The designated maintenance person must walk through all the Metroliner cars and manually record the indicated fault condition. Future plans for upgrading the remaining fleet of Metroliner cars, however, do include onboard diagnostic test equipment and the use of a minicomputer or microprocessor reporting system.

The effectiveness of onboard diagnostic test equipment should be measured by increased availability and reliability and enhanced maintainability. In the maintenance



program of Amtrak's E-60CP electric locomotive, maximum use has been made of onboard diagostic test equipment. In addition a small group of five to seven diagnostic engineers has been specially trained and strategically located to diagnose and isolate faults and ensure fast corrective action. As a direct result of these two factors, the availability or meantime-between-failure of the 26 unit E-60CP locomotive fleet was 93%* between November 1977 and October 1978.

As shown by the experiences in the passenger industry, an onboard diagnostic system can be a valuable tool in any preventative maintenance program. The system should not only indicate a fault condition but should also monitor, locate, and automatically record out-of-bound conditions before a fault occurs and provide a visual warning.

If the system is to become successful, a procedure should be developed within the maintenance facility to handle the recorded diagnostic information and expedite repairs. More than likely, the diagnostic system will require a separate trainline for multiple unit locomotive operation and a more highly skilled staff to keep it functioning. However, the advantages in terms of increased motive power availability and reliability will be well worth the effort.

* Monthly inspections were not included.

II. A True Cold Weather Locomotive — Current Production And Future Goals

Two major considerations must be met before a locomotive can be considered a true cold weather unit. The first and most obvious is that the locomotive must operate in extreme low ambient temperatures in conjunction with snow and ice conditions. The second is to minimize equipment damage should an engine shutdown occur.

To assure engine operation under extreme conditions, it is essential that delivery of fuel and combustion air be maintained. The principal cause of winter-related combustion air restriction to the engine is filter plugging with snow or ice. General Electric locomotives have as standard a summer-winter door between the engine room and the clean air compartment. In the winter position, warm engine room air is mixed with the incoming ambient air to reduce snow and ice build-up. EMD provides an EDL for the application of winterization systems to both turbocharged and non-turbocharged units.

The primary cause of fuel stoppage is waxing. The tendency toward fuel waxing can be reduced by heating the fuel while in wayside storage tanks and/or in the locomotive fuel tank. Several major points for locomotive fueling on northern railroads have wayside storage tank heating.

The builders and several northern railroads, primarily among them the Canadian National, have

developed on-board systems for fuel preheat. Basic systems have the fuel oil preheater inserted after the strainer and before the engine-mounted fuel filters. Suction side plugging — particularly at the strainer — is not appreciably reduced by the use of fuel heaters, using the basic systems. The builders have made avaiable a strainer that features a screen of a coarser mesh which is less susceptible to plugging. Pricing is such that the strainer can be considered a throw-away item, assuring a clean new condition at the start of the winter season.

Approaches used by some of the northern railroads include insertion of the fuel oil heater after the engine discharge. A small mixing tank is used to blend the heated fuel out of the engine and colder fuel out of the main fuel tank. The objective of such systems would be to obtain the optimum heat balance in the total system. Such a system of necessity adds so much heat to the fuel that maintenance of full horsepower at elevated ambient temperatures would not be possible. Therefore, an ambient-temperature-sensitive by-pass, either manual or automatic, is required.

Waxing can occur during prolonged idling at low ambient temperatures even though a fuel heater is applied, as the result of insufficient heat being added to the cooling water. Recommendations for notch three idling are being evaluated. The higher auxiliary load results in higher fuel consumption and heat rejection to the cooling water. Fuel economy may rule against burning the extra fuel, but it appears the benefits of reduced engine shutdowns will call for the adoption of this drastic measure.

Incidents of engine bogging and eventual shutdown can be traced to dirty fuel or lube filters, excitation problem or other system malfunctions. Often the engine would continue to run if the load were reduced.

General Electric has introduced several governor improvements designed to avoid shutdowns during these momentary or continuous overload conditions.

The modulating governor automatically reduces engine load and speed to match lower than standard lubricating oil or water pressure. If the fault condition is temporary, the governor automatically permits reapplication of full load and speed when the fault is eliminated. The engine will shut down if either oil or water pressure falls to the point where continued operation of the engine would be dangerous. Both derating and shutdown action are controlled by a bleed-off of speed setting oil pressure within the governor.

On CHEC excitation equipped locomotives, an overriding solenoid lever has been added to the governor. This feature causes the load control to move to minimum field in 2.5 seconds rather than 10 seconds when the governor reaches the fuel limit. This reduction in time helps compensate for the slower governor response that occurs at low ambient temperatures. This feature by itself will not prevent shutdowns due to overload but will give quicker response action to relieve some overloads.

An overload switch has been added to assist the ORS lever. When the governor reaches the fuel limit, the opening of this switch puts the locomotive into reduced excitation. It has proven to be very effective in preventing engine bogging or shutdown due to an electrical overload.

Last winter, it was determined that many unexplained low oil pressure shutdowns on GE locomotives were caused by false signals to the governor. Oil in the dead-end pipe to the governor's low lube oil pressure device would become very viscous, drastically slowing down transmission of changes in oil pressure. The dead-end pipe has been replaced with a full flow unit in which warm oil is flowing. This simple change solved a potentially serious problem.

The builders on their latest series of locomotives have attempted to minimize equipment damage due to engine shutdown on line of road. Damage to all components that contain water will result if the unit is not promptly and properly drained.

To assist in proper manual draining, drain valves have been located at a single point, color coded and tagged. Performance of automatic drain systems has been improved by insulating critical pipes and locating an improved temperature sensor in the coldest point in the water system. On GE units a flow through drain valve which uses a rolling diaphragm minimizes the probability of a stuck valve which would prevent draining. EMD offers an automatic drain system that will drain the cooling system if the engine is shut down and the water reaches 45° F.

Even on a properly drained locomotive, it has been GE's experience that oil coolers and compressors are subject to freezing. A major cause of oil cooler freezing is tubes that have become plugged, preventing their draining. An improved screen at the cooler inlet is currently in production which will effectively trap debris thus minimizing tube plugging. The tube size has been increased, which not only reduces plugging but allows the tube to drain in either direction should plugging occur. EMD has incorporated a screen into the radiator header for ease of maintenance.

The builders have made provisions for automatic draining on all of their latest series locomotives. The advent of electric cab heating has made for warm comfortable cabs, and has eliminated the problem of cab heater core freeze-up. Most of the winterization developed in the recent past systems can be retrofitted. The "art" of cold weather locomotive starting has been under intensive investigation at EMD. Several approaches to the problem have been explored and have resulted in different solutions.

The first of these is the self-contained or automotive type system. All present systems are capable of 50° F. starts. The manual injection of ether enables 40° F. starts. These start temperatures assume the locomotive has cold soaked and all systems are at the designated temperature. A word of caution on the use of ether. Special care is required to avoid engine overspeed or injury to personnel.

During the winter of 1977-78 an extensive successful test program was run to determine the cold weather startability of the EMD 16-cylinder Roots blown engine. The 35° F. Cold Start System has been designed to provide reliable starting capabilities with lube oil down to 35° F., and can be described as two complete series starting systems in a parallel connection, consisting of:

a) 4-Series Start Motors in a series/parallel connection
b) High capacity 700 amp-hour batteries

Engine purge and start motor thermal overload extras are required for engine hydraulic protection and to avoid start motor burnup due to prolonged cranking times. During the winter of 1978-79, one GP40-2 locomotive, was equipped with a similar 35° F. Cold Start System and is undergoing intensive tests to determine the cold weather startability of the EMD 16-cylinder turbocharged engine. At this time, no provision for the use of an ether injection system is incorporated into the 35° F. Cold Starting System. The increased performance of the starting system will provide adequate cranking speeds to obtain auto-ignition. On board engine starting below 35° F. and down to 0° F. would require the use of 10W40 Multi-Vis lube oil (0° F. capability), new design dual electric starting motors, higher capacity battery, battery heating, anti-freeze, and automatic ether injection.

A second approach to cold weather starting is the "layover heating system." This system has been successfully applied to the 16-645E3 turbocharged engine used on the F40C commuter locomotive. This standby system provides starting capabilitiy down to -20° F. The following equipment was required:

1. Immersion heater (15KW, 480 V. AC.)
2. Water circulating pump (10-GPM, ¼ HP)
3. Oil circulating pump (6GPM, 1 HP)
4. Industrial type lube oil cooler
5. Battery heater (0.65KW, 480 V. AC.)
6. Battery charger (480 V. AC. input, DC output)
7. *Cab heater (5.5KW, 480 V. AC.)

*The cab heater is not essential to engine starting but EMD suggests the inclusion of this component to eliminate the extremely uncomfortable condition that would exist in a cab subjected to -20° F. temperature for several hours.

In this application the water heating system and oil heating system both use circulating pumps to provide forced flow. Water heating is provided by a thermostatically controlled immersion heater while lube oil heating is accomplished by water to oil heat transfer using the lube oil cooler as the heat exchanger. This system requires the availability of a 440 volt AC 3-phase power source.

Much work has been done to provide true cold weather starting capability, yet much remains to be done. Developmental work is being done to provide starting (automotive type) down below 35° F. The committee will be kept informed of all developments.

III. Quality Control Departments And Their Effect On Maintenance Programs

In the last several years, some railroads have instituted major changes in the operation of their Quality Control departments. These changes have included the expansion of the departments' personnel and responsibilities. One railroad has increased Q. C. personnel over five-fold to represent one quality control officer per 23 locomotives and take an active part in service and repair track operations. Other railroads' Quality Control departments are responsible for locomotive material quality assurance and participate in policymaking which affects locomotive engineering.

One new development in quality control is that of locomotive in-process inspection. Quality Control identifies quality during the service, maintenance and repair operations so that all units will meet prescribed standards, as compared to final inspection, which separates acceptable units from those which do not meet the standards. Quality cannot be applied to the maintenance at a final inspection. Quality must be built into the maintenance or repair. Primary responsibility for quality is placed in the hands of production. In-process quality inspection is felt to be a better method toward improved reliability and high fleet availability. This type of inspection may eliminate unexpected repairs, and underestimated down time and materials. In-process inspection will insure the use of proper tools and materials and adherance to proper maintenance procedures: Technical assistance is provided by Quality Control to supervision and craftsmen. The quality control officer's expertise can also be used as an educational tool to train Craftsmen in proper maintenance and repair procedures.

Quality Control departments maintain a staff position within the organization. One railroad's Quality Control department is an entity outside the Mechanical department with the head of the department reporting directly to the president of the company through the director of quality control and mechanical engineering. Another railroad's Quality Control department is within the Mechanical department and its

chief officer reports to the chief mechanical officer. These organizational structures allow an insulation from production-oriented influences. The result should be greater objectivity in accomplishing the goals of the Quality Control department.

Another development in quality control has been that function's increased use of the stored information in railroads' computer data bases. Quality control statistical analysis can evaluate locomotive performance and identify failure trends within the locomotive fleet elements. This effort is intended to provide the focus needed for maintenance planning. Analysis of such parameters as locomotive age, utilization, and failure rates can help predict future needs in manpower, material, maintenance schedules and content. Therefore, more accuracy can be achieved in Mechancal department budget forecasting.

One company, which has limited shop capacity and relatively large equipment expenditures, has developed a strong "quality assurance" program to monitor its contracts and purchases from vendors. This program varies from full time, resident plant inspectors, to a group of field inspectors who will travel a given area to observe a vendor's work and shop practices and make first order inspections, spot inspections and lot inspections. Some plant inspections are very thorough and personnel are assigned in large numbers, while other inspections are of the surveillance type. The choice depends on the past or current performance of the particular vendor.

The resident plant inspectors will follow larger equipment orders, such as locomotives and car equipment, from the blueprint through the final test. They work along with the vendor's own quality control inspectors and will make acceptances or rejections on the spot so that costly returns for modifications are kept to a minimum. With strong warranty provisions being written into contracts the resident plant inspector not cnly assures the railroad of a high quality product but also that the vendor will have fewer costly post-manufacturing modifications and warranty claims.

The field inspectors will be called upon to visit a vendor's plant when a production run is begun during production or, in some cases, after the production of an item is complete. The inspector must be technically qualified to be able to detect an item that does not meet a written specification or match a drawing. Examples of items regularly inspected are:

- wheels
- electric motors and generators
- diesel engines
- passenger car seats
- steam generators
- locomotives
- new and rebuilt cars
- electric control apparatus
- etc.

Repaired and remanufactured items are inspected as well as new.

Other important functions served by the quality assurance inspectors include the inspection of a vendor's facilities to provide facts that will assist the Procurement department in determining the vendor's qualification or disqualification to perform a task or provide a service. The inspectors will also act as liaison between the vendor and the corporation for problem solving and decision making.

The director of quality assurance reports to the assistant vice-president who is responsible for procurement. This current organization has managers who supervise inspectors in specific areas — propulsion, non-propulsion and support and material test. Resident inspectors and field inspectors report to these managers depending upon the type of equipment or material being inspected.

Admittedly, a good quality assurance program is expensive to administer, particularly on the level described above. However, out-of-service and down time is more costly and service disruptions can be devastating in a competitive industry. With equipment more technically complicated and expensive than ever, any company making the investment required for new equipment should insist on knowing it is getting a product that is free of design defects and which will meet published specifications.

As can be seen in the examples described, Quality Control departments are becoming deeply involved in the responsibilities of providing reliable locomotive power. The impact and success of the Quality Control department's effort will be measured by increases in locomotive availability, craftsman proficiency, and plant production.

IV. The Training of Locomotive Maintenance Personnel to Improve Maintenance Programs

The training of locomotive repair personnel to improve maintenance is not actually a new development, but one which has become significiantly more important in the last few years.

Some of the main reasons locomotive maintenance training has become so important are:

1. Locomotive availability and reliability
2. New locomotive developments and designs
3. Shop productivity.

In the last few years, railroads have handled record amounts of tonnage. The availability of locomotives to haul maximum tonnage with an absolute minimum of mechanical-failure related delays is of prime importance. High availability and reliability require top quality maintenance which requires well trained maintenance personnel.

New locomotive developments such as Electro-Motive Division's GP40X series locomotives and General Electric's Series 7 locomotives with sophisticated modular control

and excitation systems, and the coming microprocessor monitoring and control developments, require personnel trained to troubleshoot and repair these sophisticated systems. Too many times, maintenance personnel have to learn new systems by trial and error which takes considerable time and in some cases may lead to permanent damage to expensive equipment.

New methods of component replacement and repair developed by the locomotive manufacturers may save valuable time with less chance of component damage during removal and installation. Unless maintenance personnel are trained to use these new methods, they will not be used properly or to best advantage.

New tools to assist in locomotive repair are constantly being developed that can greatly speed up repairs and in many cases can improve shop safety. Maintenance personnel must be trained to properly and safely use these tools.

New materials are constantly being developed to improve component reliability and extend component recommended changout times. Some examples are:

1. New alloys for improved wear characteristics and fatigue strength;
2. New gasket and seal materials for longer sealing life under extreme temperature and pressure conditions;
3. New filter materials for better fuel and lubricant filtering required by closer tolerances and increased bearing loadings coupled with the requirements of longer filter changeout times;
4. New lubricants that must operate under high temperature and pressure conditions of today's high horsepower engines and yet still be compatible with the new bearing and seal materials used in these engines.

Maintenance personnel must be trained in the proper use of these materials. Improper use could drastically reduce component life and lead to unexpected failure.

The third reason, and the one which has the most quantifiable results, is shop productivity. Rising material and labor costs due to inflation, work rules and labor agreements held over from the steam engine days that promote inefficiency and cause delays, and seniority rules that may prevent placing the best man on a particular job, all contribute to the possibility of low shop productivity.

In many cases, only a few people in a shop will have the knowledge required to:

1. Align rotating equipment such as air compressors, main and auxiliary generators;
2. Set fuel racks, valve clearances, and engine timing;
3. Rebuild an engine from align boring crankshaft journal bores to proper torquing procedures;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4. Rewire a locomotive or troubleshoot modular electronic control and excitation systems;
5. Rebuild traction motors, alternators and generators;
6. Perform federal inspection requirements and understand the proper completion of the required forms and documents.

Training of maintenance personnel in a thorough manner will create a shop full of qualified people capable of efficiently working any job to which they are assigned. It will also allow greater flexibility in the scheduling of off days and vacations by eliminating the small group of specialists that usually are asigned all the "difficult" work.

The type of material covered during training should not be restricted to that of a particular craft or presented only to particular crafts, but should be presented to all crafts to create a better all-around understanding of locomotive systems and system interaction.

At the Missouri Pacific heavy repair shops at North Little Rock, Ark., heavy emphasis has been placed on apprenticeship training. In addition to taking correspondence lessons, apprentices are sent to outside welding classes and general machinist classes. Apprentices are to learn, by working, as many different aspects of locomotive maintenance as possible before being qualified to journeyman status, because they are expected to be able to do any job assigned.

Management has worked to change the old attitudes towards apprentices and to encourage greater utilization of the available manpower. The apprentice is no longer expected to take a passive role, but is to be utilized to the greatest extent possible to expedite the work. Information as to the apprentice's progress is monitored and in many cases any corrective action, if required, is taken. Union leadership has backed this program to a great extent, and the quality of maintenance personnel is steadily improving. This program has been in effect for approximately one year. Although shop productivity as a result has shown a definite increase, it is still too soon to quantify the results.

In many cases, apprentice training is the last formal training locomotive maintenance personnel will receive. The locomotive manufacturers and component manufaturers such as Westinghouse Air Brake and New York Air Brake offer classes throughout the year to cover new developments in components, tools and procedures. However, the class sizes are small and in most cases only company officers and supervisory personnel are scheduled to attend. It is up to the railroads to relay this information to the maintenance personnel, and this requires some form of formal instruction.

The following section of this paper will give examples of the locomotive maintenance training programs set up by the Illinois Central Gulf railroad and Conrail.

While every training program must be tailored to the specific needs of a railroad, these programs are representative of what is currently being done.

In 1977 the Illinois Central Gulf instituted its Locomotive Technical Training Program. It is a Mechanical department function, however, much of the preparation and training of instructors has been provided by the Personnel department's training section led by the manager-training and development, manager - technical training, and technical instructors.

For the Mechanical department, the program is being coordinated by the assistant to chief mechanical officer — administration. Lesson material is arranged and edited by the superintendent of motive power, superintendent locomotive electrical, superintendent air brakes, electrical engineer-locomotive, superintendent locomotive-mechanical and quality control supervisor.

There are currently 12 locations throughout the system where classes are held, with 22 instructors. Classes are scheduled as dictated by the workload of each individual shop. Slide shows have been prepared for each phase of instruction. Projection equipment and handout materials have been forwarded to each class location. Before each phase of the program, the instructors attend a three day seminar to familarize themselves with class material and cover the fine points of instruction.

The first phase of the program was attended by all of the shop crafts directly concerned with locomotive maintenance. It was designed to be a general review of identification of individual locomotive models and systems. The second phase and subsequent phases provided separate classes for the electrical and mechanical crafts. At present five phases of the program have been completed with the sixth phase to have begun in January 1979.

The ICG believes that measurable gains are being made in locomotive availability due to the locomotive Technical Training Program.

Conrail is a railroad undergoing a massive rebuilding and it has recognized the importance that a locomotive maintenance training program can have in increasing shop productivity and improving locomotive availability.

The following information was provided by Mr. D. R. Sweetland, director training-mechanical, Consolidated Rail Corporation.

Since the start-up of Conrail on April 1, 1976, several steps have been taken toward developing a training program for locomotive maintenance personnel.

At conveyance, some training was already taking place at various locations throughout the Conrail system. Most of this training was done on a part-time basis by people who had other full-time responsibilities, training being a secondary function.

Training was being conducted at Juniata Back Shop and the Enola Diesel Terminal on a regularly scheduled basis. Facilities and personnel were dedicated to the training effort at these places and the results were encouraging.

In the Spring of 1977, the Personnel department formed a group to develop mechanical training programs geared toward the General Electric locomotives. These programs were delivered at the Selkirk Diesel Terminal, Collinwood Back Shop, and Buckeye Diesel Terminal, the major General Electric maintenance facilities.

The General Electric programs were well received. Feedback indicated that the field locations wanted even more training than was available at the time. A decision was made to develop a training program as quickly as possible.

A needs analysis was done to determine the scope and amount of training that was necessary. The data received indicated that training was needed, to some degree, by mechanics and first line supervisors in virtually every maintenance area.

The question at that time was whether there was any training material available within the railroad industry. A small task force was formed to evaluate any training material that could possibly be used by Conrail. Every potential source was visited and the material evaluated. This work was done under the direction of Dr. J. S. Shafer of J. S. Shafer Associates, an educational consulting firm from Wayne, Pennsylvania.

After the evaluation was completed, the task force spent several months writing training objectives. These objectives form the nucleus of what will become a Mechanical department training program. Over 300 objectives were written that cover everything from system theory of operation, component replacement, and troubleshooting, to rules and safety.

The task force was instructed to select 25 objectives that would have the most impact on Conrail. The task force, made up of highly qualified people from the Mechanical department, had a good idea where the greatest benefit could be achieved. The Locomotive Information System showed areas where attention was needed that confirmed the selections of the task force.

The 25 objectives have become the "priority objectives" and are the target of the initial development thrust. Courses are now being developed around these objectives and will be taught in the field as soon as they are completed.

Some of the topics being covered are: maintenance of electrical rotating equipment, troubleshooting low and high voltage electrical systems, preventative maintenance for machinists, consist preparation and servicing.

It was realized that for training to be effective and have an impact throughout the system, a large effort would have to be

made. A training organization within the Mechanical department was formed. This group is responsible for car and locomotive maintenance training.

At present, staffing is not complete. During 1979 more positions will be filled, allowing expansion of the training effort to additional terminals.

The nucleus of the organization is located in Altoona, Pennsylvania at the Juniata Back Shop. The main body of course-development is in Philadelphia. The rest of the training people are at the various terminals.

Sites have been selected to present the programs. Initially, only a few terminals will have training centers and a fulltime instructor. The instructor will coordinate the training with the local shop manager. Personnel at the terminals will have the opportunity to receive the training they need to fill any knowledge gaps they may have.

Conrail is just beginning a project that is probably one of the most important it will ever undertake; the development of its human resources.

Mechanical training programs should not be restricted just to Mechanical department personnel. Mechanical training can be used to advantage when applied to engine service personnel. If an engineman is familiar with the operation of locomotive systems, he will be better able to give a complete description of mechanical problems encountered on the road. Some types of problems will only show up on the road. A proper description of symptoms can save much time in the diagnosis and repair of locomotive problems.

Mechanical department personnel at Missouri Pacific's North Little Rock facilities are presently working on the development of a series of video tapes on various locomotive operation and maintenance subjects. The video tape medium was chosen to make use of existing facilities since MoPac uses video tape equipment extensively in the teaching of operating and safety rules. Video tape playback equipment is available at all the major terminals, most of it portable, and on the system air brake instruction car which travels throughout the system. The first tapes will be directed towards engine service personnel. Subjects to be covered will include proper procedures for shutting down and starting locomotives tied-up at outside locations, engine protective systems-devices and operation, and minor troubleshooting on the road. Later tapes will be directed towards mechanical personnel exclusively.

This paper has touched on several areas of the training of locomotive maintenance personnel. There is still much more development yet to come. Programs are well received and the results are encouraging. Locomotive maintenance training is a new development that will increase in importance in the years to come.

V. New Developments & Concepts In Locomotive Design

A. Automatic Speed Control Devices

As a result of the drive for fuel savings on locomotives, a speed control device was developed by Harmon Electronics. The system is called the Model WCO-4 Set-A-Speed System. The system is designed to minimize fuel consumption on locomotives during consist operation in high-horsepower-per-ton trains. The Set-A-Speed system works on the same principle as many fuel saving devices in use on turbocharged diesel engines which operate most efficiently at the highest throttle notch. This characteristic makes it desirable under certain operating conditions, to throttle trailing units back to the lowest position (notch 1) and leading engines to the highest position (notch 8), to take advantage of the greatest efficiency in the highest throttle notch. The main difference between the Set-A-Speed System and other fuel saving devices is that the Set-A-Speed System operates automatically, similar to automatic cruise control systems and is completely automatic after the engineer has selected the desired operating speed.

Set-A-Speed can control up to five trailing engines through a single spare trainline wire. In operation, Set-A-Speed throttles back units from the rear of the consist towards the front, thus giving the best possible train dynamics. An axle alternator is used to supply the Set-A-Speed System with locomotive speed information.

A complete Set-A-Speed System includes a control unit, an air pressure switch and two relays. The control unit can be mounted on top of the air brake control stand for convenient access by the operating engineer. The control unit is 8¾ inches deep, 7½ inches wide and only 2¾ inches high. Three indicators and three indicating push-button switches provide a visual presentation of the Set-A-Speed operation.

In operation, the engineman brings the locomotive throttle out to 7th or 8th notch and when the train has accelerated to the desired operating speed, he depresses the "set speed" switch on the Set-A-Speed control unit. The Set-A-Speed system will automatically reduce trailing unit throttle positions to 1st notch progressively, or back to 8th notch as needed to maintain the set speed. Horsepower requirements will dictate how many units can be cut back at any given time. Moving the lead engine throttle to any position other than 7th or 8th notch, or an air brake application, forces the Set-A-Speed System into a "hold" mode. In the "hold" mode, units previously throttled back remain in that status but automatic speed control ceases to function. A "restore power" switch is provided to drop out automatic control, whenever desired, thus restoring normal throttle response in the lead engine controls.

Set-A-Speed Systems are also available for normally - aspirated engines and may be used anywhere in the consists, the only difference in operation being that it will run at 5th notch (its most efficient position), rather than at 8th notch.

The Set-A-Speed Systems are also available which will drop trailing units to the 3rd notch position for cold weather operation. This will also insure locked wheel protection on certain locomotives.

An automatic speed control system is also under development by the Kansas City Southern Railroad.

The Set-A-Speed System by Harmon electronics and the automatic speed control system under development by the Kansas City Southern Railroad are currently being tested and we hope to be in a position to report results in the future.

Like the many fuel saving devices tested previously, the amount of savings is greatly dependent on the type of train operation. This same rule, of course, would apply to an automatic device.

The automatic device has the advantage of taking the "guess work" away from the engineer; however, at the same time the automatic device under certain changing grade conditions, speed regulations, train orders, etc. could lose its effectiveness and possibly cause adverse conditions and, therefore, can be manually overridden.

B. General Electric's New Turbocharger

An unacceptable failure rate of turbochargers on GE locomotives is one of the factors that helped GE decide to manufacture their own turbocharger.

With the introduction of the GE turbocharger to full production, a long term development program is meeting its established objectives. As of January, 1979, over 800 GE turbochargers had been built and placed in service.

When the program was initiated, two of the key objectives were:

a) Improved performance

b) Improved reliability.

Results of the field test through production units show that the objectives were accomplished.

Improved Performance

1) Engine specific fuel consumption has been improved due to increased air flow and turbocharger efficiency. The actual fuel saving is dependent on the locomotive horsepower and duty cycle.
2) Pre-turbine temperatures have been reduced by 80° F. on 16 cylinder engines applied to 3600 HP locomotives.
3) Cooler turbo operation allows the intermediate throttle notch speeds to be reduced for the 3600 HP application, resulting in an overall fuel saving.
4) The 3600 HP locomotive is now capable of delivering full horsepower to 8000 ft. altiitude.
5) Improved manufacturing control and tighter tolerances have reduced performance variations between machines.

Improved Reliability

1) Turbine inlet assembly design has been changed to eliminate failures.
2) The compressor is now a one-piece design which should provide improved life and performance.
3) An improved oil seal has eliminated leakage with the present locomotive configuration.
4) Turbine design resulting in reduced stresses and aerospace material provides longer service life.

Maintenance was also of prime concern in establishing the initial design. For example, one model turbocharger is applied to the 16 cylinder engine regardless of horsepower rating. This standardization is naturally a benefit in manufacturing but it also helps the railroad parts inventory. In a similar manner, the turbochargers for the 8 and 12 cylinder engines—again one model per engine regardless of horsepower—utilize many common parts.

In conclusion, it is felt the advances made in the GE turbocharger in the area of fuel economy and overall performance will benefit all concerned. We, as a committee, are hoping for the best results for increased life of the GE turbocharger in the future years of field use.

C. The Testing and Performance of New Model Locomotives:

In our 1978 paper we presented an introduction of the new model locomotives, EMD's GP-40X, General Electric's B 30-7 and Morrison-Knudsen's TE 70-4S. This year we will report on various tests conducted on some of these locomotives and will briefly summarize some of the test results.

The Southern Pacific Railroad has been and is still testing each of the above model locomotives. At the time this report was written the test results are not yet available, but the structure of the tests will be presented.

OBJECTIVE

The objective of these tests was to make comparative evaluation of the newer model four axle locomotives furnished by EMD (GP 40X), General Electric (B 30-7) and Morrison-Knudsen (TE 70-4S). Tests were made on both single units of each model and in a four-unit road consist of the same make to determine the following:

1) Coolant efficiency during tunnel operations in the Sierras and Cascades.
2) Tractive effort of a road consist on mountain grades.
3) Tractive effort characteristics of individual models.
4) Adhesion characteristics by test on Tehachapi grade using rated tonnage, then increasing the tonnage.
5) Energy efficiencies in both standing tests and in over-the-road comparisons.
6) Accuracy of on-board power meters in comparison with dynamp measurements.
7) Comparison of ride quality characteristics of each model locomotive over selected areas.

COOLANT EFFICIENCY RESULTS

Cascade Tunnels

These tests were run with a target speed of 15 mph aimed for by control of either the road or helper consist which operated opposite to the four unit test consist. Throttle control on this opposite power was regulated so that the test consist was in throttle 8 position throughout the tunnel area.

Sierras, Tunnel 41

These tests were run with target speed of the train entering Tunnel 41 at 18 mph and with the road power in throttle 8 and helper power remaining in a steady reduced throttle position. This speed can be obtained by controlling speed through Shed 47 to 14 mph.

TRACTIVE EFFORT TESTS

Four Unit Road Consists

The four unit road consists of each individual locomotive model were run in revenue freight runs in round trips from Roseville to Ogdon and from Roseville to Eugene.

During the Roseville-Sparks run a cautious, intentional throttling back of helper consist was made to give spectrum of tractive effort down to minimum continuous speed. The complete average TE from drawbar and electric horsepower is now being programmed for computer output.

Individual Units

The single unit tractive effort tests were made on the 1.5% grade, tangent track segment east of Bakersfield The test train with 967 tons trailing the unit being tested was accelerated with an accompanying test unit which was isolated when the train reached the desired initial test speed.

ADHESION TESTING

Tonnage Test

A train with six carloads of stone, an isolated locomotive unit, instrument car SP-252, and caboose totaled 843 tons and was used with change-out of the isolated unit in each test. This total tonnage closely matches the rating as shown in guidelines of 850 tons per unit for this grade. Tests were run from MP 338 to 353.

Tonnage Test

The second adhesion test was performed with each locomotive by adding an additional 124-ton car of stone to bring total trailing tonnage to 967 per unit through the test area from MP 338 to 349. This tonnage exceeds the unit rating by about 14%.

Fuel Tests

Fuel consumption tests were made on a weight basis by burning a predetermined amount as measured from drum supply of fuel on platform scales at each throttle position. Duplicate runs were made for each throttle position. Corrected net horsepower, based on 93.8% engine efficiency from current and voltage readings were made while operating on the load box at the Roseville Search facility. Appropriate auxiliary horsepowers were added in for each locomotive make to furnish a gross horsepower yield for each throttle position.

On-board Power Meters

These meters measure in megawatt-hours and register on dual read-outs, one being a permanent total and the other a resettable "trip" total. The measurement is based on power to one traction motor. These meters were never applied to the Prototype GP-40X units.

Ride Quality Tests

These data were taken on a Sangamo analog tape deck and monitored on a Brush oscillograph. RMS values for accelerations are to be programmed through an H-P computer for analysis. Data were taken over specific areas and these will be analyzed at a later date.

In the future we hope to present the test results and conclusions drawn from this comprehensive test program.

The Santa Fe has been involved in tests with the GP40-X locomotives and has some very interesting results to report: Fuel tests were conducted on an 11,075 trailing tons unit coal train, using 3 classes of EMD power, the converted SD24's, the SD40-2 and the GP40-X. This operation is a 2,164 mile round trip with a 96-hour turnaround time. The territory represents a combination of a number of environments, i.e. mountainous, desert, high and low altitudes, grades and curves.

The fuel measurements were accurate, on-board measurements, and were taken by a test crew accompanying the trains. The GP-40-X and SD40-2 locomotives were less than a year old, and the SD-24's had been recently rebuilt (to SD26 with the 645 assemblies). A comparison of the fuel consumed (equated on a gallon/ton of coal handled to eliminate discrepancies resulting from small differences in tonnage between the various test trains) showed the GP40-X to handle the train using 7% less fuel than the SD40-2 (both using eight units to handle the train, and the rebuilt SD24's to use 11% more fuel than the SD40-2 (eight units of SD40-2 vs. nine units of the SD24), and the SD24's used almost 20% more fuel than the GP40-X.

In a comparison of the speeds with which the GP40-X handled the train on grades versus the SD40-2, with eight units of each on the trains being compared, the additional horsepower of the GP-40-X units (3500 HP vs. 3000 HP) was quite evident. These comparisons were made on long steady grades at the same locations for both classes of power, and on a 0.6% grade the speed comparison was 45 mph for the GP40-X vs. 40 for the SD40-2, 23 vs. 17 mph on a 1.4% grade and 19 vs. 14 mph on a 1.7% grade.

The GP 40-X was also tested in a TOFC train handling 100 loaded trailers, and compared to the handling of a similar train (100 loaded trailers and the same rail cars) powered by SD45-2 locomotive units between Chicago and Los Angeles. The train was handled with three locomotive units in both instances. The fuel savings with the GP40-X again turned out to be the same 7% on this high-speed train as previously realized on the heavy unit coal train operation. Speeds on grades were very comparable between the train powered with the 3500 HP GP40-X and the 3600 HP SD45-2.

Drag tests were also made on the GP40-X comparing it to the SD40-2. These tests were performed on a 28-mile grade of 1.4% in desert ambient temperatures up to 116° F. last July. In these tests, the locomotive was loaded with 100-ton cars of ballast to a point where it would be operating at its continuous ampere rating on this grade. The four-axle GP40-X unit handled 2025 tons per unit under these conditions ,while the six-axle SD40-2 handled 2090 tons. The wheel "creep" action on the GP40-X when in "super series control" was readily noted during this series of tests, and it was amazing to those observing the test as to the adhesion that can be developed without the use of sand.

As with all innovations, there have been some problems, although not of an extremely serious nature. The manufacturer's representatives have been very attentive to dealing with these problems and are presumably making plans for correction in any future units to be produced of this type. Again, it should be recognized these units were put out as experimental locomotives, for the purpose of developing service experience and determining where problems exist. On the other hand, it should be mentioned that a goodly number of the problems that have developed with the GP40-X units are of a type similar to those experienced in other locomotives produced in recent years. In six test runs on the coal train (including power of both manufacturers) with knowledgeable observers aboard, there was not one run in which some type of failure did not occur and these were with locomotives from three weeks to 10 months in age. It has been said that if the space program had had this kind of reliability, we would have never put a man on the moon. In all fairness, there is quite a difference in the cost of millions of dollars for a moon shot as compared to the $600,000 to $700,000 for a new locomotive, but really, for the amount a new locomotive costs today, we should realize a greater degree of reliability. It should not be necessary to dispatch an extra unit or units on a train just for "insurance."

Many of the problems encountered are in the modules, and often the problem can be corrected with a soldering iron, correcting such items as a cold solder joint or a broken wire. Such problems raise questions as to the effectiveness of quality control, and whether such components are subjected to any type of effective environmental testing.

The subjects discussed in this paper have been quite diverse, but all have a common purpose: to make a better locomotive. At one point in this paper we expressed the idea that "the less maintenance required allows for the best maintained vehicle." We ask that all concerned with new locomotive developments keep this simple thought in mind.

Tuesday, September 18, 1979

2:00 P.M.

REPORT OF THE COMMITTEE ON FUEL AND LUBRICANTS

Pre-Convention Presentation:
West Burlington Shop
Burlington Northern, Inc.
Burlington, Iowa

May 16, 1979
Holiday Inn
Burlington, Iowa

J. D. SMALLING, Chairman
Chemical Engineer
Southern Pacific Transportation Co.
One Market Plaza, SP Building
San Francisco, CA 94105

VICE CHAIRMAN

B. C. Cain, Chemist, Atchison, Topeka & Santa Fe Railway Co., 1001 N.E. Atchison, Topeka, KS 66616

COMMITTEE MEMBERS

M. B. Abernathy, Manager Surface Transportation Sales, Continental Oil Co., Houston, TX 77046
R. A. Bjorndal, Senior Staff Engineer, Chevron, Inc., San Francisco, CA 94104
V. E. Broman, Project Engineer, Atlantic-Richfield Co., Harvey, IL 60426
J. P. Fite, Engineer of Tests, St. Louis-San Francisco Railway Co., Springfield, MO 65802
E. A. Goff, Industry Sales Executive-Railroad Sales, Mobil Oil Corp., AMF O'Hare, IL 60666
J. A. Gombold, Engineer of Tests, Burlington Northern, Inc., St. Paul, MN 55101
W. C. Hamilton, Engineer of Tests, Louisville and Nashville Railroad Co., Louisville, KY 40201
J. F. Hillard, Senior Project Engineer, Texaco, Inc., Beacon, NY 12508
J. G. Hoffman, Fuel and Lubricant Engineer, General Electric Co., Erie, PA 16501
D. D. Hudgens, Lubrication Engineer, Union Pacific Railroad Co., North Platt, NE 69101
M. W. Kwiatkowsky, Technical Engineer, Electro-Motive Division, GMC, LaGrange, IL 60525
W. R. Land, Product Engineer, Amoco Oil Co., Chicago, IL 60601
C. Lenzini, Engineer of Tests, Missouri Pacific Railroad Co., St. Louis, MO 62103
D. T. Murray, Assistant Mechanical Supervisor, Norfolk & Western Railway, Roanoke, VA 24042
R. T. Newman, Senior Chemist, Southern Railway Co., Chattanooga, TN 37401
K. D. Reed, Director, Research Laboratory, Consolidated Rail Corp., Cleveland, OH 44110
O. J. Rider, Laboratory Supervisor, Chessie System, Cumberland, MD 21502
R. P. Schmidt, Marketing Technical Services, Exxon Co. USA, Houston, TX 77001
P. A. Shackelford, Manager of Tests, Illinois Central Gulf Railroad, Paducah, KY 42001
S. P. Spargo, Engineer of Tests, Bessemer & Lake Erie Railroad, Greenville, PA 16125
J. L. Wilkison, Products Application Engineer, Shell Oil Co., Houston, TX 77002

1979 TOPIC:
"FUEL AND LUBRICANT INNOVATIONS"

PERSONAL HISTORY

JOHN D. SMALLING

Born in El Dorado, Arkansas on July 13, 1926 Mr. Smalling attended local public schools and upon graduation from High School enlisted in the United States Air Force. Following his tour of duty in the Air Force he attended Louisiana Polytechnic Institute at Ruston, Louisiana for two years, afterwhich he started his railroad career as a Laboratory Technician for the St. Louis Southwestern Railroad in 1947 in Pine Bluff, Arkansas. He was married to Betty Goodwin of El Dorado, Arkansas the same year and they have a married daughter who received her degree in Architecture from the Univrsity of Houston and is nôw a registered architect working in Corpus Christi, Texas.

In 1958 Mr. Smalling returned to school at Little Rock University (which is now the University of Arkansas at Little Rock) attending evenings and also working weekends in order to attend day classes. Six years later and after some 80,000 miles of commuting between Pine Bluff and Little Rock he received his Bachelor of Science Degree in Chemistry.

In 1969 Mr. Smalling was transferred to San Francisco as a Special Assistant in the Mechanical Department of the Southern Pacific Transportation Company. He later moved to Sacramento, CA as Superintendent of Laboratory Operations for four years, subsequently returning to San Francisco in 1974 as Engineer of Tests where he is presently assigned as Chemical Engineer.

Mr. Smalling has been active on the LMOA Fuel and Lubricant Committee for twelve years. He is presently serving on the Executive Committee of the National Railroad Lubrication Council and is a member of the National Association of Railroad Engineers of Tests.

THE RECLAMATION OF USED RAILROAD LUBE OILS

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INTRODUCTION

The objective of a modern reclamation process is to produce, by re-refining of used oils, base stocks that meet new or virgin oil performance requirements of the engine builders and users.

Nearly all railroads in North America have been recycling locomotive diesel engine oil during the past three decades. The volumes of additives and contaminants contained in engine drain oil have increased significantly during the past ten years. The changes have occurred with the increase in specific power output by engine builders and the increase in engine oil drain intervals by the railroads. The principal reason for this early start in recycling was large volumes of locomotive diesel engine drain oil available at railroad maintenance facilities. Without recycling, the physical handling and disposal of this waste oil would be a significant problem because annual drain oil volumes is as much as several hundred thousand gallons at individual maintenance shops. A systematic disposal method is needed to handle such volumes. Recycling supplies the needed method at both a savings of money and conservation of a limited resource.

Two factors promote the continued expansion of lubricating oil recycling. These are:

1. Environmental considerations
2. Conservation of resources

One reason the processing of used railroad oils is less complex than other used oils is the similarity of the chemical and physical characteristics of locomotive diesel engine oils. They are:

1. Uniformly high viscosity (SAE 40)
2. Uniformly moderate viscosity index (60-75)
3. Zinc additive metal is absent

High-speed diesel and automotive gasoline engine oils, with a few exceptions, contain a substantial quantity of zinc as an additive metal. As a result, the re-refiner handling both types of oil must have two processing systems —one for locomotive diesel engine oils to prevent contamination with high V.I. oils and with zinc containing additives, and a second separate system for other lubricating oils.

The re-refiner of locomotive diesel engine oil must produce a finished product that will satisfy the complete lubrication performance demands of modern high specific output medium speed 2-cycle and 4-cycle locomotive engines.

To do this he must process a drain oil that contains considerable amounts of water and fuel in addition to the insolubles, dirt, wear metals, combustion soot, depleted additives, and other contaminants normally present in used railroad crankcase oils. This adds up to the removal of all non-lube oil material so as to produce a base stock equivalent to the virgin base oil initially used in blending the engine oil.

The following topics will be covered in this review of the re-refining of locomotive diesel engine oils.

- —Historical Background
- —Engine oil contaminants
- —Additives effect on re-refining processes
- —Current commercial re-refining process
- —Federal legislation affecting the disposal of waste lubricating oils
- —Generation and disposal of waste oils.

Historical Background

The railroads of North America have the lead in the recycling of diesel engine lubricating oils primarily because of the large volumes available at their centralized maintenance facilities. Using a capacity of 250 gallons for the average locomotive, the total volume for engine oil in service at any one time in North America

approximates 6,800,000 gallons; total annual usage is estimated at 61,000,000 gallons.

The volume of used locomotive diesel engine oil has been declining over the past twenty years. Engine oil drain intervals have increased dramatically with improvements in additive technology. Prior to the early 1960's, oil drain recommendation and practice was every ninety days, regardless of oil condition and without regular sampling and laboratory analysis. This drain oil was suitable for recycling with relatively simple processing. Processing consisted of heating and steam stripping to drive off water and fuel dilution, followed by activated clay filtration to remove oxidation products, soot and other contaminants. Many railroads operated their own re-refining units. They recycled the diesel engine drain oil at the point of collection. However, as additive technology improved the existing oil recycling units were unable to cope with the additive and contaminant load. Today, all re-refining and refortifying of locomotive engine oils is performed by commercial re-refiners with the necessary technology to make quality base stocks and supply quality lubricants.

Engine Oil Contaminants and The Role of Additives

Contaminant loads carried by the locomotive diesel engine oil have continued to rise over the past thirty years as a result of:

1. Advances in additive chemistry and increases in compounding levels.
2. Changes in engine manufacturer's oil condemning limit recommendations.
3. Extension of oil drain intervals.
4. Increased engine specific power output.

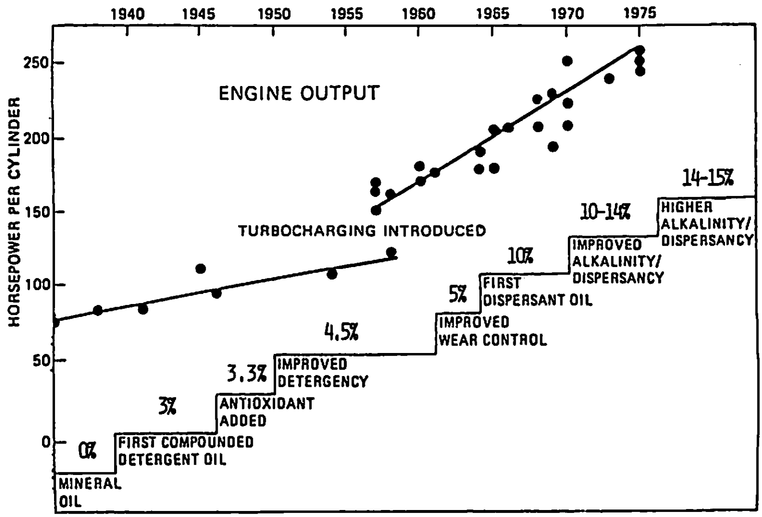
Table one lists the generally recognized diesel engine oil con-

DIESEL ENGINE OIL CONTAMINANTS

Table 1.

CONTAMINANTS	SOURCE	EFFECTS
Dirt	Airborne	Abrasive Wear
Oxidation and Nitration Products	Combustion	Oxyacids and Varnish, Lacquer
Sulfur Acids	Sulfur in Fuel	Corrosive Wear
Soot	Incomplete Combustion	Sludge & Viscosity Thickening
Wear Metals	Engine Parts	Catalyze Oxidation
Fuel	Incomplete Combustion	Reduced Lubricity & Oil Pressure
Water	Combustion and Leakage	Sludge & Bearing Distress
Anti-freeze (Other than Railroad Diesels)	Coolant Leakage	Heavy Sludge & Varnish

PROGRESS IN U.S. RAILROAD TYPE ENGINES AND LUBRICANT ADDITIVES



WITH APPROXIMATE ADDITIVE DOSAGE % ADDED

FIG. 1

taminants and their effect on engine and oil durability.

For the engine user to obtain maximum engine durability, a conservative change interval should be established for the air and oil filtration systems. Oil condemning limits should be set to allow oil changes before additive depletion and/or saturation occurs. Since the

TABLE 2, ROLE OF ADDITIVES

Typical Volume	Type	Purpose
3-8%	Dispersant	Control Sludge/Varnish Lacquer/Acids
1-3%	(Detergent	" " "
	(Alkalinity	Neutralize Acids
	(Rust Inhibitor	Protective Film
1-2%	(Oxidation Inhibitor	Improve High Temperature Stability
	(Anti-Wear Agent	Form Protective Film
3-10%	Viscosity Index Improver	For Multi-Vis Grades (Other than locomotive diesel engine oils)
6-20%	TOTAL VOLUME	

re-refiner must cope with both the contaminant load as well as active and depleted additives, the type and concentration of additives is an important factor.

Figure 1 shows the approximate volumes of additives used in developmental step, accompanying the rise of additive levels in locomotive engine oils over the past thirty-five years.

A knowledge of the types of additives used in modern heavy-duty engine oils is important to the technology required for the re-refining of these oils. In particular, the introduction of ashless dispersants during the early 1960's, and the rapid increase in dispersant levels during the past ten years resulted in the need for a pre-cleaning step in the processing of crankcase drain oils.

The types and typical additive volumes used in engine oils and their functions are summarized in Table 2. Both gasoline and diesel engine oils are included.

The role of additives and contaminants in engine oils re-emphasizes the premise of recycling: Lubricating oil is the waste receptacle for the garbage generated in or ingested by the engine. The contaminated oil must be recycled through the reclamation process to regenerate high-quality base stocks. The re-refining process removes, by a combination of physical and chemical treatment, such material as:

Fuel dilution
Sludge
Oxidation and nitration products
Anti-freeze/water
depleted additives

These contaminants add up to about 8-25 percent by volume of the drained oil.

Re-Refining Processes

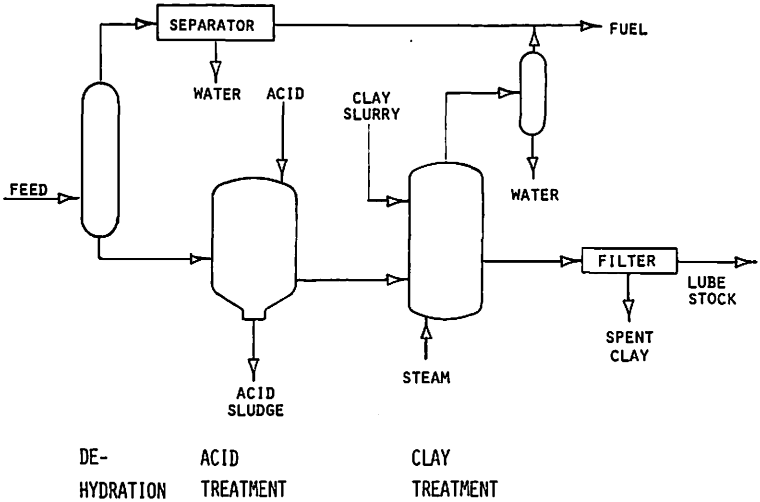
Until the early 1960's, drain oils could be separated into a clear upper phase simply by standing and settling. When ashless organic dispersants were introduced, agglomeration of insoluble particles was reduced, the volumes of soot and oxidation products held in suspension increased along with solubilized organic acids, and appreciable quantities of water.

Waste oil reclaimers using the old method were faced with the need for a chemical process to "break" the additives so both the contaminants and additives could be removed. The acid/clay process allowed re-refiners to adjust by using pretreatments and increasing the severity of acid treatment.

1. Acid/Clay Process

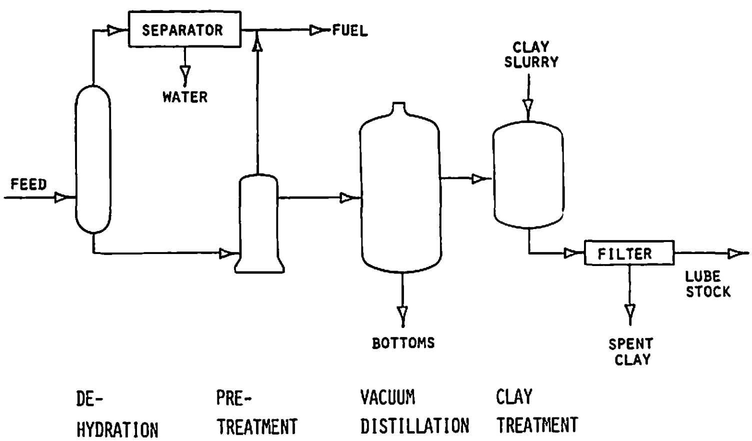
Acid/Clay is the most commonly used re-refining process in the world. At least 21 U.S. and three Canadian plants operated with this technology. It is similar to the acid/clay treating method used by the petroleum industry. The process starts with dehydration, followed by treatment with sulphuric acid.

A flow diagram for the acid/clay process is shown in Figure 2. The dehydration step removes water, fuel and solvents. Sulphuric



RE-REFINING BY ACID/CLAY PROCESS

FIG. 2



RE-REFINING BY DISTILLATION/CLAY PROCESS

FIG. 3

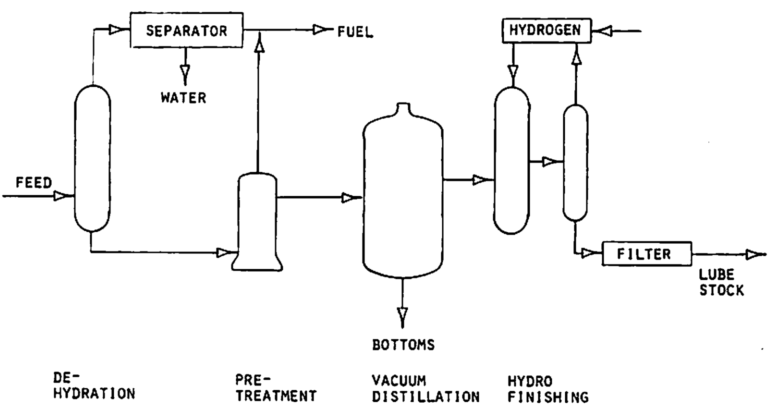
acid is then mixed with the oil. An acidic sludge is formed which settles out in 24 to 48 hours and is removed for disposal. The acid treated oil is heated and clay-contacted to remove color bodies and remaining contaminants. The spent clay is removed by filtration, producing a quality base oil product.

Acid Sludge Disposal

Re-refiners have had difficulty with the disposal of acid sludge produced by the acid/clay process. In some areas, acid sludge has been classified as unacceptable for disposal in land fills or burning in incineration equipment. In the case of landfill disposal, acids, metals and organic compounds can be leached from the sludge leading to possible environmental problems. Incineration produces large amounts of sulfur oxides and metal bearing fly ash of sub-micron particle size. These are emitted with the stack gas. The remaining metallic ash requires safe disposal.

2. Distillation/Clay Process

Figure 3 is a flow diagram of the combination vacuum distillation/clay process. A pretreatment step, which partially cleans the used oil, can reduce fouling in the distillation equipment. Vacuum distillation separates the lube oil from all suspended solids, degraded products, additives and other non-boiling or high-boiling materials. These "tower bottoms" are neutral, of high viscosity, and usually high in ash and solids content. This material can be used as an asphalt extender. The distillate lube oils are treated with clay to remove any polar products and filtered, producing high-quality finished product lubrication base stocks.



RE-REFINING BY DISTILLATION/HYDROFINISHING PROCESS

FIG. 4

3. Distillation/Hydrofinishing Process

Figure 4 shows the distillation/hydrofinishing process. It is identical to the distillation/clay process through the vacuum distillation step. Then the distillate lube stocks are mixed with hydrogen in a catalytic reactor under high temperature and pressure to produce stable base stocks. Light viscosity oils are stripped off with steam, leaving high-quality lubricating oil as finished products.

The three processes, Acid/Clay, Distillation/Clay, Distillation-Hydrofinishing are those commercially used in North America today.

The Physical, Chemical and Performance Properties of Re-Refined Oils

In Table 3, the wear, additives and other contaminant metals in used locomotive diesel drainings is compared with the elemental data for re-refined base stocks. The effectiveness of the re-refining processes is shown by the contaminants removed and the similarity of the re-refined and virgin stocks.

Table 3
COMPARATIVE TYPICAL METALS ANALYSES OF DRAIN OILS WITH RE-REFINED AND VIRGIN BASE STOCKS

Contaminants, ppm	Locomotive Engine Drain	Re-Refined	Virgin
WEAR METALS			
Iron	40	1	0
Chromium	65	0	1
Aluminum	5	1	1
Lead	35	0	0
Copper	20	0	0
Tin	10	0	0
ADDITIVE METALS			
Barium	150	0	2
Calcium	2100	0	0
Magnesium	20	0	0
OTHER CONTAMINANTS			
Boron	20	0	0
Sodium	310	3	2
Silicon	20	1	0

The physical/chemical properties of the re-refined base oil stocks are essentially the same as new virgin base stocks. Table 4 compares the new with reclaimed base stocks. Note the low ash and the similarity of the gravity and viscosity values.

Table 4
PHYSICAL PROPERTIES COMPARISON OF RE-REFINED WITH VIRGIN BASE STOCKS

	Railroad SAE 40 Base Oil Re-Refined	Virgin
Viscosity		
@ 37.8°C, cSt	185	195
@ 100°F, SUS	855	900
Viscosity		
@ 98.9°C, cSt	13.7	14.0
@ 210°F, SUS	73	74
Viscosity Index	71	64
Gravity, Specific	0.9047	0.9042
°API	24.9	25.0
Flash Point, °C	260	240
°F	500	465
Ash, % Mass	Nil	Nil
Insolubles	Nil	Nil

Bearing metal corrosion tendency and oxidation stability of unused locomotive engine oils are usually measured by the EMD L.O. 201-47 bench test method. Strips of copper and silver, immersed in oil, act as oxidation catalysts and allow measurement of corrosive attack on these two metals by visual appearance and change in weight. Oil samples are analyzed to determine changes from fresh oil properties like viscosity, pH, total acid number, total base number, and pentane insolubles.

Table 5 gives results of duplicate runs in the EMD test at 325°F (163°C) with re-refined locomotive engine oil base stock compounded with three different generation 3, (10 TBN type) commercial additive packages.

Table 5
EMD L. O. 201-47 SILVER CORROSION TEST
72 HR. @ 325° F (163° C)

	#1	#2
Re-Refined Oil A		
Viscosities cSt		
@ 37.8°C - New	214	212
% Increase	11.3%	11.9%
@ 98.9°C - New	15.32	15.45
% Increase	5.3%	5.7%
TBN, D-664		
New	6.38	6.53
Final	3.65	3.99
Insolubles, Final	Nil	Nil
Silver Strip		
Wt. Loss, MG	–0.7	–1.0
Copper Strip		
Wt. Loss, MG	–4.0	–2.6
Re-Refined Oil B	#1	#2
Viscosities cSt		
@ 37.8°C - New	224	223
% Increase	17.2%	16.6%
@ 98.9°C - New	15.60	15.50
% Increase	8.4%	8.2%
TBN, D-664		
New	6.40	6.79
Final	3.92	3.99
Insolubles, Final	Nil	Nil
Silver Strip		
Wt. Loss, MG	–0.6	–0.4
Copper Strip		
Wt. Loss, MG	–6.6	–6.0
Re-Refined Oil C	#1	#2
Viscosities cSt		
@ 37.8°C - New	225	222
% Increase	11.7%	11.1%
@ 98.9°C - New	15.90	15.80
% Increase	6.7%	6.6%
TBN, D-664		
New	7.96	7.96
Final	4.33	4.12
Insolubles, Final	Nil	Nil
Silver Strip		
Wt. Loss, MG	–1.0	–0.5
Copper Strip		
Wt. Loss, MG	–2.5	–1.2

The results of the EMD Silver Corrosion Test show that the three oils are non-corrosive, retain base number, as well as control viscosity increase. However, to be acceptable to all concerned parties, re-refined oils must be continuously checked with a carefully chosen and widely used quality control program to insure performance level. In addition to the use of bench screening tests, we suggest re-refined oil inspection tests showing viscosity flash and fire plus ash level and insolubles be used as part of a purchase specification.

Engine Dynamometer tests have been run in commercial testing laboratories for re-refined base stocks and selected additive packages. These oils were compounded with additive packages designed for API SE/CC (MIL-B) performance. The oils passed the four SE sequence engine tests on the first attempt. The tests demonstrate quality level of re-refined oils under engine conditions.

Legislative Status and Impact

Three recent Federal Legislative actions will have a significant influence on the recycling of oil. They are:

1. The Energy Policy and Conservation Act of 1975.
2. The Resource Conservation and Recovery Act of 1976.
3. The Model States Recycling Act.

The major consequences of these legislative actions are:

1. Federal agencies must revise purchase specifications, where necessary, to allow the use of recycled petroleum products.

2. Federal agencies must purchase recycled lubricants when feasible and practicable.
3. The FTC must change the labeling requirements for those recycled oils proved to be "substantially equivalent" to virgin oils.

These legislative actions will result in increased emphasis on collection and recycling of used oils.

Recycling of used oils is a fact of life with most U. S. Railroads. Recycling is an economical way to handle large volumes of used oils without pollution of the environment. Quality level of railroad re-refined oils is a prime concern. It must be maintained to accommodate engine builder and user performance requirements. A continuing program to check quality needs should be adopted by re-refiners as well as users so that base stocks continue to be produced that are "substantially equivalent" to virgin oils.

The second very significant reason for legislation promoting recycling of used oils is the need for conservation of a limited resource. Re-refining is a good way for petroleum users to "do their part" for environmental protection.

Summary

Because of their early involvement, the North American Railroads are considerably ahead of others of the transportation industry and other U. S. and Canadian engine manufacturers in the use of recycled engine oils.

Table 6 gives the total gallon estimates and sources of waste lubricating oil generated in the U. S.

Table 6
USED LUBRICATING OIL SOURCES — 1977 ESTIMATE

Source	Usage Gallons	Waste Oil Generated Gallons
Automotive	1,113M	623M
Indust'l - Lubricating	865M	467M
Indust'l - Process	364M	84M
TOTALS	2,342M	1,174M

The nearly 1.2 billion gallons of waste oil generated each year is a large volume worthy of conservation. This volume of waste oil is equivalent to between $500 million to $600 million worth of lubricent base stocks, and could be recycled as high-value products. Unfortunately, most of this waste oil is lost or burned, and only a small amount is recycled into useful fluids and lubricants (Table 7).

Table 7
ESTIMATE OF WASTE OIL DISPOSITION — U. S. (1977)

Gallons	End Use	Problem or Hazard
500M	Burner Fuel	Loss of efficiency from ash buildup on heat transfer surfaces. Metal oxides in stack gas.
190M	Road Oiling	Run-off into fields, streams.
	Land Fill	Metals into food supply chain.
360M	Sewer System	
150M	Re-Refined	None (with vacuum distillation)

Of this 1.2 billion gallons of oil wasted annually, only about 150 million gallons or 12.5 percent is re-refined and recycled. However, in the case of locomotive diesel engine oil, the recycling ratio is strikingly different. Of the 61 million gallons used by the Railroads each year, about 15 percent, or nearly 10 million gallons is captured for recycling. This amount represents about 80 percent of the available drainings generated by locomotives.

This successful re-use of a valuable resource is both a money saver and an outstanding example for all other engine users.

The re-refined and recompounded locomotive engine oils have a remarkable thirty-five year history of successful performance in the railroad diesel engine. The increased dispersant/detergent levels of additive technology have kept pace with and complemented the increase in specific engine output by the engine manufacturers. As a result of these changes, the re-refiner has had to develop new chemical and physical processing to cope with the increased levels of contaminants and additives found in current generation diesel oils. The new distillation re-refining processes are environmentally acceptable. Such equipment requires large capital investments to satisfy environmental requirements. This investment dictates a large-capacity plant and a high-volume throughput in order to meet economic targets with a reasonable return on the capital invested. Because of the excellent record of engine performance, the economic benefits and the environmental factors, we believe the recycling of all engine oils will increase at an accelerated rate over the next few years. As this occurs, other segments of the transportation industry will realize benefits from the conservation of engine lubricating oil.

RECLAMATION OF CHROMATE WATER AND WASTE OIL

A. CHROMATE WATER

Because of EPA restrictions, chromate treated water can no longer be dumped into sewers and drainage systems. Railroads thus have two choices, (1) change to a different type of water treatment or (2) reclaim the chromate water. Because of the superior inhibitive properties of chromate treating over other available water treatments, some railroads have chosen to reclaim the chromate water.

This is done by transferring the engine cooling water into a holding tank. Here, any oil that may have been in the system is skimmed off. The water is then transferred into a larger holding tank through filters to remove sedimentation. Raw water and chromate concentrate then are added to bring the concentration up to the recommended strength. This treated water is then used to refill the engine cooling system.

B. WASTE OIL

1. **Reclamation for use as a power plant fuel.**

Waste oil skimmed from pollution ponds is largely diesel fuel. This may be contaminated with small amounts of lube oil, car oil and air compressor oil. A recent survey of several railroads shows a typical recovered oil would be as follows:

1 — 5% sludge
5 — 10% water
1 — 20% lube oil
Balance — diesel fuel oil

The recovered oil is placed in a separator and allowed to settle. After settling, the water and sludge is drained off. Filtration then gives a recovered oil ready for use as follows:

Less than 1% — Water and Sludge
1 - 25% — Lube Oil
Balance — Diesel Fuel Oil

This oil can be sold for 15-18 cents per gallon, but used as a fuel for power plants it will replace fuel selling for 38-41 cents per gallon.

2. **Disposal by Land Farming**

Land farming is a natural process using available bacteria in the soil to degrade waste oil and sludge. Typically, the waste oil and sludge is spread on the ground and mixed with the top layer of soil. The waste — soil mixture is then tilled periodically to provide an aerobic environment for the bacteria. Water and nutrients (fertilizer) may be added. Lime is used to keep the soil alkaline. The end products of the degradation are carbon dioxide, water and increased humas content of the soil. Degradation rates on the order of 800 - 1000 barrels of oil per acre per year have been achieved.

EFFECTS OF ENGINE MODIFICATIONS ON FUEL AND LUBE OIL

The energy crisis has created problems for railroads, particularly in the cost of fuel. Fuel costs have risen to all-time highs and fuel is now the highest single operating cost of the railroad industry. With decreasing availability and rapidly increasing cost of fuel oil, efficient use of this energy source becomes essential; unnecessary waste is a luxury we cannot afford.

Refineries will not have the flexibility as in the past to produce a consistent fuel product as their sources of crude oil change. The sulphur content, cloud point, gravity and distillation range will approach the limits of our specifications. Average sulphur content will probably rise. The relationship of sulphur content to engine wear is a well-documented fact. The gravity will probably drop as heavier ends are squeezed from the crude and the distillation range extended. This will give a fuel with higher BTU ratings, which would actually result in slightly higher horsepower for the same rack setting. This, in itself, is not deleterious. However, the combustion characteristics of the higher boiling ends could affect the insoluable content in the oil since

these ends would need higher combustion temperatures and / or longer combustion duration to produce the end products of carbon dioxide and water. Using current refining processes, we will likely see the cloud point rise.

Last winter, temperatures averaged 15 degrees F. or more below the seasonal norms in some areas of the country. Some railroads discovered the disastrous effect of fuel having cloud points only meeting specifications. However, lower cloud fuels could be maintained by blending in the more expensive stocks now going to the aviation industry. But with the increased airline business, there is unlikely to be any excess stocks for blending.

We must make our locomotives operate on fuels with marginal cloud points. This could be accomplished by higher capacity fuel heaters and/or containment of the heated fuel in the main fuel tank. The cost of these modifications would, in the long term, save the railroads money, both in the cost of fuel and from costly delays caused by plugged fuel strainers and filters.

General Electric and EMD both are cognizant of the problems created by the energy crisis for the railroads. They have modified their engines in recent years to (1) increase fuel efficiency, and (2) reduce lube oil consumption.

Since 1971 EMD has made changes in the piston, cylinder liners and injectors to reduce exhaust emissions and improve fuel efficiency. The 645 Roots blown engine developing 137.5 BHP per cylinder, now uses a piston with the top ring ¾-inch from the top of the piston. Cylinder liner port width has been modified twice since 1971, and the low sac injectors were introduced in 1974. The 645 turbocharged engine, rated at 206 BHP per cylinder in the 16-cylinder models and 195 BHP per cylinder in the 20-cylinder models, has used a piston with the top ring located 1¼-inch from the top of the piston since 1972. Cylinder liners and injectors are the same as in the Roots blown engine. The low sac injector introduced to help reduce exhaust emissions has reduced the amount of dribble after the injector stroke. Although the amount of dribble from a single injector would seem insignificant, when multiplied by the number of injectors in operaticn over a period of time, the savings become more significant. Moving the ring belt higher on the piston effectively increases the power stroke ¾-inch in the blown engine and ¼-inch in the turbocharged engine. Here again, the changes are small, but long-term savings are demonstrated in the more efficient use of the fuel.

Changes in the liner ports have improved the aspiration of the engine. Better and faster purging of the waste gases from the cylinders and charging with fresh air have contributed to engine efficiency. These modifications to the engine have resulted in a reported

3.7 percent improvement in the blown engine and a 1.1 percent improvement in the turbocharged engine in the specific fuel consumption for the medium road duty cycle. This improvement may be better appreciated if one were to consider that the 16-cylinder 645E3 engine consumes approximately 400,000 gallons and the 16-cylinder 645E engine approximately 320,000 gallons of fuel per year when operated on the medium road duty cycle with an availability of 90 percent. The annual savings would be 4400 gallons and 11,800 gallons respectively

EMD currently is testing a more efficient turbocharger with higher air flow and a new design injector that will increase the injection rate and combustion efficiency. These improvements are expected to increase fuel efficiency approximately 2 percent over the current 16-cylinder 645E3 engine.

Modifications to major components of the General Electric engine since its introduction in 1960, have resulted in a reported 8 percent improvement in fuel consumption through 1978. Changes in the intercooler, exhaust system, pistons, cylinder liners and turbochargers have been responsible for this improvement. Those changes have been made to improve the quantity and efficiency of airflow through the engine, to lighten the piston and provide better ring to liner seals.

We now turn to the effects of engine modifications on the lube oil. As previously noted, modifications emphasize reduction of lube oil consumption. General Electric can now achieve a 0.5 gallon oil use rate per 100 gallons of fuel at 80 percent full load duty cycle. The nominal oil consumption rate for EMD's 16-645E3 engine at rated load and speed is 0.5 gallon lube oil per 100 gallons of fuel oil using standard cast iron liners and standard ring set #8467250 (which incorporates 140 psi #6 oil control ring #8464953).

The logical consequence of reduced consumption is reduced make up. The reduction of make up reduces the addition of fresh additive to supply the alkalinity, etc. lost during operation. Thus, we see that the new oil supplied at a change will be subjected to greater stresses because it will not be rejuvenated to the same extent as previously was the case. Reduction in consumption of lube oil may decrease the crankcase life of current generation oils, leading to more frequent changes. This may give the impression that little is gained by such design changes. However, as pointed out in the Diesel Mechanical Maintenance report to the LMOA in 1974, a reduction of 0.5 gallon oil per 100 gallons fuel consumption rate will result in a 26 percent overall reduction in total usage even when accompanied by a 33 percent shorter crankcase life.

The reduction in consumption by EMD has been achieved by increasing ring to cylinder wall

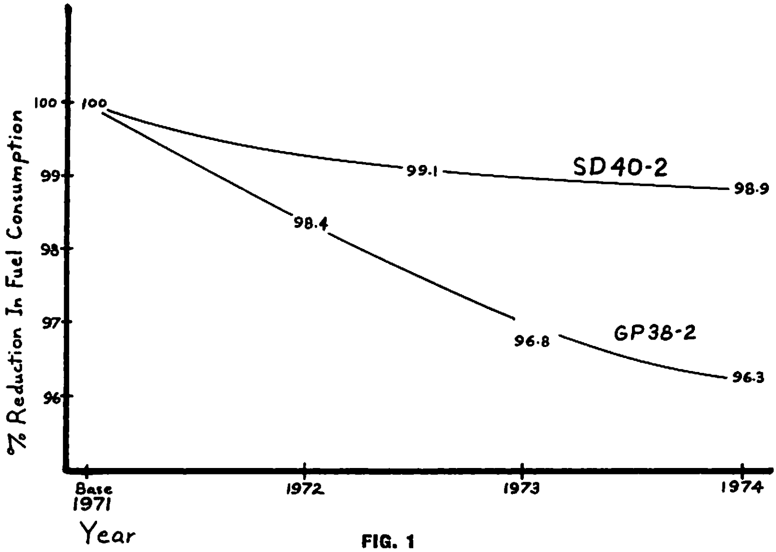

% Reduction In Fuel Consumption
100
99
98
97
96
100
99.1
98.9
SD40-2
98.4
96.8
GP38-2
96.3
Base
1971
1972
1973
1974
Year

FIG. 1

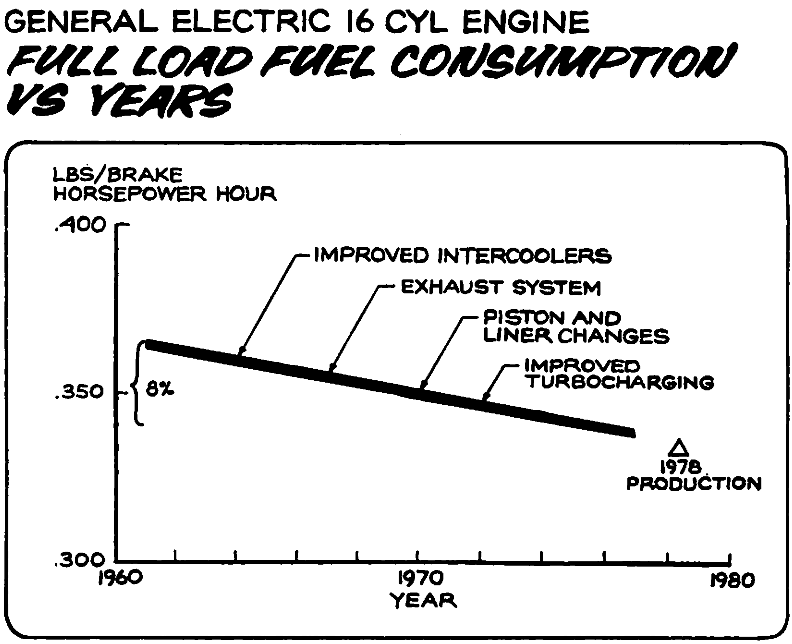

GENERAL ELECTRIC 16 CYL ENGINE
FULL LOAD FUEL CONSUMPTION
VS YEARS
LBS/BRAKE
HORSEPOWER HOUR
.400
.350
.300
8%
IMPROVED INTERCOOLERS
EXHAUST SYSTEM
PISTON AND
LINER CHANGES
IMPROVED
TURBOCHARGING
1978
PRODUCTION
1960
1970
1980
YEAR

FIG. 2

pressures and changes in the ring belt on the piston. These changes require that the lubricant maintain film strength between the ring and cylinder walls as pressures increase. Moving the ring belt closer to the top of the piston, as EMD has done, increases the amount of heat to which the oil is subjected; and the oil's stability will be vigorously tested. Less stable oils will cause carbonacious material to form in the ring grooves, making rings stick, with known consequences. Interestingly, some of the modifications that improved fuel efficiency in the General Electric engine, also improved performance to such a degree that the demands on the lube oil were also reduced. Piston temperatures above the top ring were reduced to 50 percent at the same power output level. Had the temperature improvement not been accomplished, the horsepower rating increase that went on simultaneously between 1960 and 1978 would not have been feasible.

As lube oil consumption is further reduced, requirements of the oil will be moving in the direction of (1) higher available base, (2) improved oxidation resistance and, (3) better dispersancy.

1. Higher base number oils will be needed because reduced consumption will raise the apparent sulphur content of the fuel, even though it would remain constant, since the oil would be required to neutralize the sulphur in a greater quantity of fuel. Similarly, other acidic products formed during combustion would have to be neutralized by the oil.
2. Oxidation resistance would also be severely stressed as it is called upon to do its job for longer periods of time in more hostile environments.
3. Better dispersancy will be needed because of the greater debris load carried by the crankcase supply, particularly in a four-cycle engine.

These functions must be combined in a balanced complimentary package that will satisfactorily lubricate the changing engines of today. Your committee thinks the railroads, engine builders and oil suppliers should continue to work together in the investigation of new and better products to improve the availability, efficiency and reliability of our motive power.

IMPORTANT NOTICE

Your committee has been advised that supply of crude needed to formulate Medium VI (Naphthenic) lubricants has become critical for some major suppliers. Therefore, to meet the needs of railroads, some oil companies may be forced to introduce High VI (Paraffinic) products in the immediate future.

During the interim period of several years when MVI and HVI oils are mixed, it will be most important for railroads to modify their method to determine their viscosity at 210° F. rather than at the most commonly used tem-

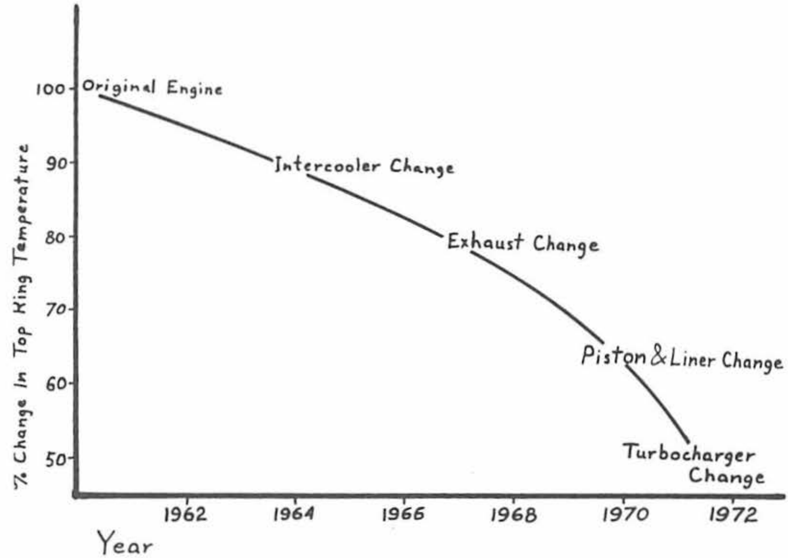

Original Engine
Intercooler Change
Exhaust Change
Piston & Liner Change
Turbocharger Change
% Change In Top Ring Temperature
100
90
80
70
60
50
1962
1964
1966
1968
1970
1972
Year

FIG. 3

perature at 100° F. Since the typical viscosity characteristics of railroad oils at 100° F. vary from 700 SSU (for HVI) to 1000 SSU (for MVI) oils, it would cause erroneous interpretation of fuel dilutions and result in unnecessary oil changes. The viscosity characteristics of HVI and MVI oils at 210° F. are 76 SSU and 82 SSU respectively. Because of the small differential viscosity range, interpretation of results would remain ineffective at this temperature.

Your railroad laboratories can easily make this change without adverse effects on accuracy or operation.

AIR COMPRESSOR, GOVERNOR AND THE NEW AAR JOURNAL BOX OILS

Air Compressor Lubrication

The basic component parts of a reciprocating air compressor are: the piston and cylinder in which the air is compressed, the crank mechanism that imparts the reciprocating motion to the piston, and the valves that control the admission and discharge of air to the cylinder.

Proper lubrication is essential to satisfactorily lubricate all three. Valves must be lubricated without impairing their action by the formation of carbon. Piston and cylinder must be lubricated with minimum oil carry-over and freedom from ring sticking. The bearings of the mechanism must be lubricated and protected against corrosion, with minimum friction.

Of the parts of a compressor requiring lubrication, the discharge valve will be considered first because, not only is a compressor's performance determined by its valve action, but it is the hottest spot and most critical from a lubrication standpoint.

The intake valve usually presents no lubrication problem since it is kept cool by the incoming air. It is lubricated by oil, which inevitably gets by the piston rings. This same oil lubricates the discharge valves.

The discharge valve, of course, will be at the temperature of the compressed air since it is located in the air stream. If the discharge valve leaks, the added heat, because of the cycling of air back and forward past the valve, will raise the temperature above normal for the compressor. If an intake valve is leaking, the hot air from the discharge stroke will heat up the intake passages, preheat the intake air and result in higher than normal discharge temperatures.

One of the easiest ways to form carbon is to spread a thin film of oil on a hot surface, which is exactly the condition existing at the discharge valve. Since carbon formation is detrimental to good valve action, it is highly important to use an oil that will form the least carbon.

Laboratory tests and services experience show that the most volatile oils form the least carbon (Figure 1). Therefore, solely from

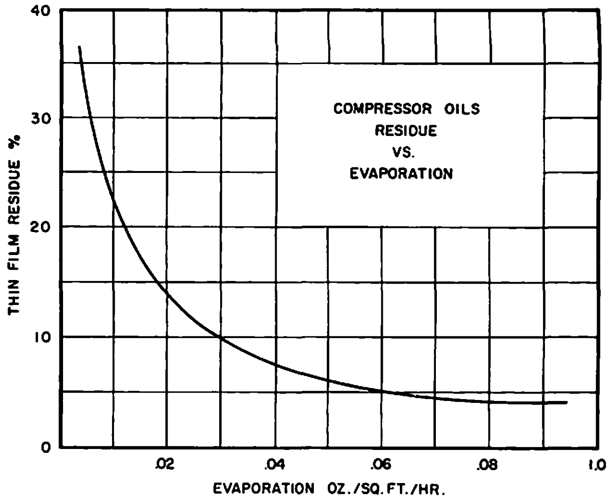


FIG. 1 - COMPRESSOR OILS RESIDUE VS. EVAPORATION

FIG. 1

a valve operation standpoint, where carbon buildup is a problem, as light and as volatile an oil as possible should be used in the compressor.

Cylinder lubrication conditions, however, require an oil of a certain viscosity. For a given viscosity the naphthenic oils are most volatile, form the least and softest carbon and are preferred for air compressor lubrication where carbon is a problem (Figure 2). Cylinder requirements determine the type of oil that should be used in the crankcase. Since most cylinders are best lubricated with a 300 second oil, the temperature of the crankcase oil should be accommodated to this grade. This means the oil temperature should be kept under 160° F. to keep oil consumption to a minimum.

A large sump increases the life of the oil by keeping the oil temperature down and giving it a chance to rest instead of being continuously exposed to oxidizing conditions in the compressor environment.

One of the problems encountered in compressor lubrication is that as wear increases, increasing amounts of oil pass the piston rings and result in excessive carbonization of the discharge valves

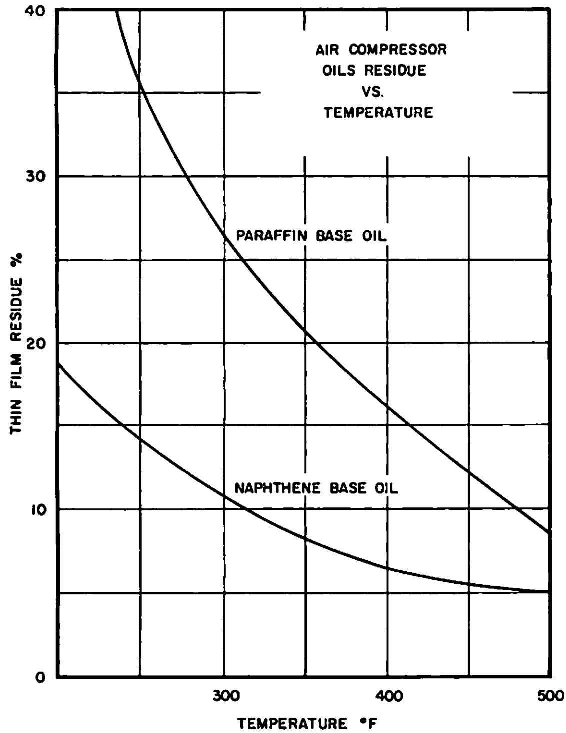


FIG. 2 - AIR COMPRESSOR OILS RESIDUE VS. TEMPERATURE

FIG. 2

and increased discharge temperatures. Improper ring configuration, oil type and viscosity can also cause excessive oil carry-over and the same resultant problems. Wear is not ordinarily a problem in compressor lubrication, provided the oil and air are kept clean. Excessive wear is generally associated with contamination of the intake air. Misalignment, improper piston and ring clearance and inadequate cooling will also cause increased wear.

Gardner-Denver and EMD have for several years recommended for use in air compressors a turbine-type lube oil with anti-rust, anti-oxidation, and anti-foam inhibitors. They state that detergent-type oils or oils containing polar-type additives should not be used because they will result in stuck rings, stuck valves, lacquering of

the machine, and high oil consumption.

Owing to the considerable difference in volume of the deep sump and shallow sump machines, an SAE 10 oil is recommended by EMD for the deep sump machine and SAE 30 is recommended for the shallow sump machines. Lube oil temperature in the deep sump crankcases at operating temperature is approximately 50 degrees less than in a shallow sump crankcase. With the EMD recommended oil in each type of crankcase, this would give approximately the same viscosity for each oil at its respective operating temperature.

Some railroads have had a degree of success in using a 20 or 30 weight, or even 40 weight oil for all compressors. Tests have shown that the gear pump machines now available are more tolerant of heavier oils in cold weather than the piston-type pump machines. However, for the most satisfactory service Gardner-Denver and EMD continue to recommend a 10 weight oil for all deep sump machines. Also, EMD states that the oil pump in the compressor will cavitate at approximately 20,000 Saybolt seconds. This means a deep sump compressor will stop pumping oil at about 15° F. with 30 weight oil and at 43° F. with 40 weight oil. Those temperatures can easily be reached during long unloaded cycles in winter. Regularly starting cold machines containing heavier than recommended lube oil could unknowingly be deteriorating the bearings on each start, thus reducing the life of the machine.

Some railroads have inquired about the use of multi-vis oils in air compressors. EMD does not recommend using those oils since they all are detergent-type oils, which are unsatisfactory for air compressor use.

G. E. recommendations for air compressor lubrication varies from EMD in that G. E. requires anti-wear additives. Those will usually be Zinc dithiophosphate additives. G. E. recommends a 90 VI, 10 weight oil for Gardner-Denver compressors under all ambient conditions, a 20 weight 90 VI product for Westinghouse compressors under normal ambient temperatures, and a 90 VI nominal 215 vis. @100° F. for compressors operated at low ambient temperatures.

Governor Oil — Desirable Characteristics

When oil foams or retains air, it becomes a compressible fluid, and governor response becomes unstable. Oil that foams makes a governor inoperable. Even a properly adjusted mechanically perfect governor will hunt, if the oil foams or retains air.

The range of viscosity recommended by Woodward for optimum governor operation at normal operating temperatures is 100 to 200 S. U. S. (Figure 3). Low viscosity oil decreases pump capacity through leakage and requires a critical needle valve setting. High viscosity oil makes the governor sluggish. An oil with a high vis-

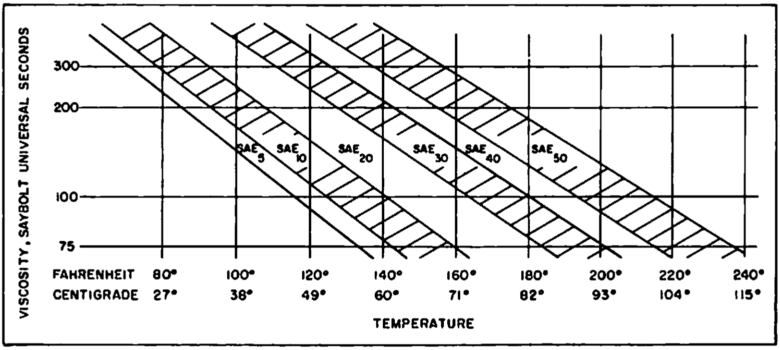


Figure 3. Average SAE Designation for Oils in the Viscosity-Operating Temperature Range Recommended for Use in Woodward Governor/Actuators

FIG. 3

cosity index has a small change in viscosity with a change in temperature. This minimizes the effect of high viscosity when starting cold. When operating temperatures vary widely a multi-viscosity oil may provide the required range in viscosity needed.

Sludge and varnish formation causes excessive wear on moving parts; friction, which slows response; and sticking, with resultant control failure. In some cases where sludge is present, a detergent oil may be necessary to hold sludge particles in suspension. This type of oil also promotes cleanliness in the system by loosening and removing deposits.

Oxidation and rust inhibited oils are desirable. Tight tolerance of governors allow no room for rust particles, since moving parts may jam and lines may clog owing to rust and sludge build-up.

The pour point of the oil chosen should be 15° F. to 20° F. below the lowest starting temperature when the governor and its oil has cooled to ambient.

The oil should also be non injurious to oil seals. Oil that damages seals induces leakage and makes the governor inefficient.

Contamination and oxidation are the chief causes of oil failure. There are several visual indications of oil deterioration. Those are the presence of sludge, varnish, a dark or cloudy color, and sediment. Frequent inspection of the oil can reduce the possibility of clogged or damaged governors. Dirty, fatigued oil must be changed, as this creates the largest percentage of governor failures.

Woodward states that synthetic lubricants may be used in its governors. Those lubricants are less likely to form sludge or coke under high heat conditions. Synthetic lubricants usually allow a wider operating temperature range and will often run indefinitely without changing. There are some precautions to be observed when going to a synthetic oil. When storing, keep from contamination by water or dirt. Hydrolysis from water may break down the oil. Even though some synthetic and petroleum oils will mix, it is good practice not to mix the two. When going to a synthetic oil, carefully observe governor operation and check for leakage. Check also for foaming. Some synthetic oils have poor air release characteristics and can cause governor instability.

Locomotive Builder Recommendations

EMD recommends that a heavy SAE 30 or light SAE 40 turbine-type oil containing rust and oxidation inhibitors be used in all governor applications. They specify a viscosity range @ 210° F. of 65 to 75 S. U. S., a typical Viscosity Index of 100 and a maximum pour point of 0° F.

G. E. states that in most cases SAE 10W-30 grade SE quality level lubricating oil is recommended for governors operating under ordinary temperature conditions. If conditions of operation are extremely hot, it may be desirable to use SAE 40 or 50 weight oil. In any case, the oil must not contain additives which are used to free up rings, remove carbon, etc., unless a non-foaming additive is also present. The oil should not foam or sludge when agitated, or form gummy deposits when heated.

A. A. R. Specification M-963-78 All-Year Journal Box Lubricating Oil With Rust Inhibitors

Since this specification will replace current Specifications M-906, Journal Box Oil and M-906-A Journal Box Oil for Free Oiling, it is appropriate to review briefly the development of these two specifications.

M-906 Journal Box Oil was adopted in 1955. Basically, this was an all-year grade, non-additive lubricating oil having the following properties:

Flash Point, min.	350°
Viscosity, 210° F	53-58 sec.
Viscosity Index	100 min.
Pour Point, max.	–20° F

Four years later, in 1959, the AAR Committee on Lubrication of Cars and Locomotives began considering the specification for Journal Box Oil for Free Oiling, now designated as M-906-A. It was adopted in 1960 and covered two grades of lubricating oil — one for summer and one for winter, having the following properties:

	Summer Grade	Winter Grade
Flash Point, min.	350° F	350° F
Viscosity at 210° F	68-71 sec.	43-46 sec.
Viscosity Index, min.	80	80
Pour Point, max.	0° F	–20° F

Essentially, those three oils were non-additive lubricating oils. It must be realized that the authors were unyielding on restricting the use of pour point depressants and viscosity index improvers. In regard to VI improvers, this was justified since the additives developed in the 1950's were found to gradually deteriorate in normal service due to poor shear stability. However, the oils as proposed were not premium quality oils, and the specific requirements for viscosity, viscosity index, and maximum pour point, etc., were arrived at through compromise.

The adoption of M-906-A, with its two grades of oil for free oiling, made available three grades of oil for the lubrication of the plain bearing. The fact that three approved oils were available presented considerable misunderstanding and problems as to how and when each should be used. Also, it presented undreamed of logistic problems for the Purchase and Stores Departments in making available the proper grade of oil at the right time for all points on a railroad system.

The specifications indicated that only M-906 Journal Box Oil was to be used for saturation of both waste packing and lubricators. Further, the use of M-906-A oils was not mandatory but rather to be used as a guide by those railroads desiring to use a summer weight or a winter weight oil (depending on the season) in lieu of M-906 oil for free oiling.

It is obvious from the test results of oil samples taken from journal boxes during surveys made by railroads represented on the WABL Committee as recently as 1976 and 1977 that the problem with having the improper or wrong oil in the journal box had not been resolved during the 16 to 17 year period.

The requirement limiting the ash content to 0.10 percent to control and hold to a minimum the amount of undesirable contaminants or sludge resulting from poorly or inadequately re-refined crankcase drainings was not adopted until 1966.

As previously mentioned, in regard to oil additives, members of the AAR Committee on Lubrication in 1959 were adament in their views on the use of viscosity index improvers and pour point depressants. However, there was concurrence among them on the benefits of lubricity and load-carrying additives present in premium-grade oils offered during this period.

Corrosion leading to pitting of journals is a condition that has plagued the industry for years. This condition was generally found after long periods of idleness, such as when cars were in storage or even after short periods when awaiting loading and/or unloading. The highest incidence of pitted journals occurred in regions of high humidity and marine environment such as exists along the eastern and southern coastlines. A separate study by the former PRR

indicated that pitting corrosion of journals also prevailed in highly industrialized regions where the concentration of sulphur dioxide in the atmosphere was relatively high. Inspections indicated that the pitting was caused under conditions of high humidity when moisture would condense on the cold journal surface as the temperature dropped during the night and early morning hours. Canadian and U. S. railroads operating in the northern regions also experienced similar corrosion of journals resulting primarily from prolonged contact with water-laden journal box oil and lubricators.

Following the study of the corrosion pitting of journals made by the AAR Research Department in October 1959, it was concluded that the best solution to the long-term problem would be through the use of an additive in the journal box or through the application of a chemical that is sprayed on the journal surface at the time the car is idled. The use of vapor phase inhibitors was also suggested to reduce the corrosion of journals of stored cars.

The best solution to the short-term problem was thought to be by addition of a corrosion inhibitor to the journal box oil to protect the journal surface against corrosion. The AAR laboratory tested several rust inhibitors:

Alamine 21	General Mills-Chemical Div.
Diam 26	
WS-3516	Esso Standard Oil Company
WS-3517	
WS-3518	
Gulf Agent 178	Gulf Oil Company
Conoco AN-110-A	Continental Oil Company

Those preliminary studies indicated that the Alamine 21 and Diam 26 offered the best protection against corrosive attack. Since the recommended concentrations for the primary and secondary amines were 5 percent and 1 percent, respectively, it was felt at this time that the expense of the oil-additive blends at these concentrations would be prohibitive. It was also felt that effective additives should not require concentration levels higher than 0.5 percent.

On the basis of the laboratory findings, the recommendation was made for field or service testing to substantiate the results. While several inquiries were made requesting oil-inhibitor blends for service testing, the results of the service tests were never published.

It was not until May, 1966 (7 years later) that the subject of corrosion or rust control was revived by the SP member who brought to the attention of the Lubrication Committee the fact that some car journal oils were better than others in the ability to control rust. The committee was in general agreement that a rust-inhibiting property for car journal oil was needed, providing a test could be devised for evaluating it.

While the subject of corrosion-inhibitor additives continued to be discussed, no action was taken until January, 1970. At this time, the committee consensus was that a corrosion inhibitor was not re-

quired in Specification M-906 and M-906-A for normal operating conditions. However, the committee did request the AAR Research Department to investigate a means to prevent journal corrosion on stored cars.

The subject of corrosion-inhibitor additives lay dormant another five years until the spring of 1976, at which time the MP member was requested to draft an instruction for servicing journal boxes of plain-bearing cars to be placed in storage. In addition, a request was made to the AAR Technical Center for recommendations on test procedures for journal box oil additives (rust-preventative additives).

A survey of journal box oils was made by the Southern Railway in July, 1976, on cars crossing its repair tracks. It was found that 32 percent of the plain-bearing-equipped cars had the wrong oil or a mixture of summer and winter grades, thus raising the question as to whether placement of the proper lubricant was controllable. It was suggested that members of the committee conduct similar limited surveys to determine if seasonal grades of journal box oil should be eliminated on the basis that a substantial number of cars were operating on the wrong grade of oil or mixtures of oil for the season. These limited surveys substantiated that 24-27 percent were indeed operating with the wrong oil.

Also in 1976 an Ad-Hoc Committee was assigned to study proposed Interchange Rules modifications dealing with pitted journals because they remain a major operational problem and a significant hazard to the industry. It was evident that the problem of pitted journals was concentrated to a very high degree within the plain-bearing tank car fleet. It was noted that while tank cars comprised only 10.1 percent of the total plain-bearing fleet of cars, they accounted for 53.2 percent of the indicated plain-bearing pitted journals, at a cost of $5,712,000 for repairs. That cost did not include losses from derailment damages stemming from pitted journals, lost car service time, etc.

Further, the Ad-Hoc Committee felt that the problem of pitted journals warranted prompt remedial action to eliminate or reduce the existing costs to the industry as well as to reduce the accident potential. It was also felt that failure to act decisively might well lead to additional regulations.

Included among several recommendations of a subcommittee was "That the WABL Committee investigate the inclusion in journal box oil of rust-preventive additives in sufficient quantities to alleviate rusted and pitted journals."

With the concurrence of the General Committee and in light of the successful use of rust-inhibited oils by several railroads such as the C&NW, MP and Shippers Car Line, the WABL Committee was requested to reconsider a specification for "All-Year Journal

ASSOCIATION OF AMERICAN RAILROADS
MECHANICAL DIVISION

Manual of Standards and Recommended Practices

Specification M-906-78 — "All-Year Journal Box Lubricating Oil," with rust inhibitor.

Adopted: 1978

Effective Date:

1. Scope. These specifications cover the requirements for an all-year journal box lubricating oil for use in saturating lubricating devices, free oiling of journal boxes or other uses.

Properties and Tests

2. Properties. The all-year lubrication oil shall conform to the following:

Items	Methods of Test *	Requirements
(1) Flash, min.	ASTM D-92	177°C (350°F)
(2) Fire, min.	ASTM D-92	193°C (380°F)
(3) Kinematic viscosity At 99°C (210°F)	ASTM D-445	
10^{-6} m^2/sec (CS)		6.03 — 9.64
SSU		46 — 58
(4) Viscosity Index, min.	ASTM D-2270 Table XI	100 min.
(5) Pour Point, Upper max.	ASTM D-97	-37°C (-35°F)
(6) Moisture, max.	ASTM D-95	0.10%
(7) Pentane Insolubles	ASTM D-893 Procedure B	0.10%
(8) PH	ASTM D-664	pH 6.5 to 9
(9) Ash, %	ASTM D-482	0.10%
(10) Rust-Preventing Characteristics Test	ASTM D-665 Procedure A — 24 hr., min.	No Rust
(11) Corrosion — Humidity Cabinet	Note (1) ASTM D-1748 100% RH — 100 hr.	No More Than 3 Dots

FIGURE 4

Box Lubrication Oil" with rust inhibitor.

Given this impetus, the WABL Committee solicited the expertise of the Technical Center's lubrication engineer and consultant for the committee in writing the first draft of Specification M-963, which was to be patterned after Specification M-906-71 and to include tests for evaluating the rust inhibitor.

The attached first draft of the specification (Figure 4) was admitted to the WABL Committee in January 1978 for its consideration and review. The final draft is shown in Figure 5.

Important items, the requirements of which were arrived at through discussion and balloting, which naturally involve compromise are:

1. Viscosity — Range

ASSOCIATION OF AMERICAN RAILROADS
MECHANICAL DIVISION

Manual of Standards and Recommended Practices

Specification M-963-78 — All-Year Journal Box Lubricating Oil.
Adopted: 1978
Effective Date: March 1, 1979

1. Scope. These specifications cover the requirements for an all-year journal box lubricating oil with rust inhibitors for use in saturating lubricating devices, free oiling of journal boxes or other uses.

Properties and Tests

2. Properties. The all-year journal box lubrication oil shall conform to the following:

	Items	Methods of Test*	Requirements
2.1	Flash, min	ASTM D-92	177°C (350°F)
2.2	Fire, min.	ASTM D-92	193°C (380°F)
2.3	Kinematic viscosity At 99°C (210°F) SSU	ASTM D-445	53—58
2.4	Viscosity Index, min.	ASTM D-2270 Table XI	125 min.
2.5	Pour Point, Upper max.	ASTM D-97	-37°C (-35°F)
2.6	Moisture, max.	ASTM D-95	0.10%
2.7	Pentane Insolubles	ASTM D-893 Procedure B	0.10%
2.8	PH	ASTM D-664	pH 6.5 to 9
2.9	Ash, %	ASTM D-482	0.15%
2.10	Rust-Preventing Characteristics Test	ASTM D-665 Procedure A — 24 hr., min.	No Rust
2.11	Corrosion — Humidity Cabinet	Note (1) ASTM D-1748 100% RH — 100 hr.	No More Than 3 Dots

*Means to the latest ASTM test method.

FIGURE 5

2. Viscosity Index
3. Ash Content

The new specification allows for the use of:

1. Pour point depressants to attain a pour point of -35° F.
2. Viscosity index improvers to attain a VI of 125 for this essentially multi-grade 10W-30 oil.
3. Rust inhibitors.

As a final note, locomotive maintenance officers can be assured that the lubricating oil compounded to meet M-963-78 is a premium-grade multi-vis, rust-inhibited lubricating oil far superior to other non-additive journal box oils and which may be used with confidence in lubricating traction motor support and oil-lubricated roller bearings on locomotives.

NEW SPECTROSCOPIC TECHNIQUE

Within the past year, the General Electric Company Transportation System Division has installed a new emissions spectrometer. This instrument is a Jarrell-Ash Model 975 Plasma AtomComp. It has both a plasma energy source and a spark energy source and is direct reading. The new feature of this instrument is the plasma energy source. We shall not attempt here to discuss the instrument and method at a depth appropriate for the analytical chemist or physicist. An excellent paper of that type may be found in **Analytical Chemistry Volume 46, No. 13, November, 1974.** In addition, G. E.'s J. C. Smith will soon publish an article on the use of this technique in the quantitative determination of trace elements in used lubricating oil.

An article by Dr. Arthur W. Varnes of Standard Oil Company, Ohio, compares wear metal analysis of used motor oil by different techniques. The opening sentence reads, "Wear metal analysis of lubricating oil has become an established technique for preventive maintenance operations in truck fleets." He also refers to the fact that there was a "Popular Science" article in August of 1977. While the use of the spectrometer as a scientific tool of the analytical chemist pre-dates the dieselization of the American railroads, it was the railroad industry that led the way for its use as a maintenance tool for reciprocating internal combustion engines and rotating engines. Pioneers in this include the late Ray McBrian of the Denver, Rio Grande and Western; Wade Seniff, retired, Baltimore and Ohio; L. S. Crane, President of the Southern Railway; Cliff Mugford of the Southern Pacific; V. E. Amsbacher, former Chief Chemist, Pennsylvania Railroad and Art Mengel of the American Locomotive Company.

These pioneers recognized the potential of quantifying the wear metals in the engine crankcase oil as a preventive maintenance tool. At an early symposium on this topic, one of them reported ashing 50 gallons of oil to obtain a sufficiently large sample for wet chemical analysis of the wear metals. Incidentally, he reported that they nearly burned the laboratory down three times in the process. Others reported ashing two to three liters for this purpose. It was obvious that another technique was needed and spectroscopy was that technique.

The spectrum has been defined as an ordered arrangement of radiation according to wave length. Electromagnetic radiations have been discovered having wave lengths of almost every value from thousands of kilometers to fractions of millimeters. Since no single instrument is known to exist able to separate all of these wave lengths into a spectrum, the electromagnetic spectrum has been conveniently divided into regions in accordance with the various wave lengths.

In using the techniques of spec-

troscopy, one either studies the intensity of the radiations emitted under various physical conditions or studies the radiations which are absorbed as they pass through different types of matter. Some railroad laboratories use instrumentation for absorption, but most use emission-type procedures. Each type of atom can be made to produce its own characteristic set of spectrum lines. At very low concentrations of the elements, the amount of light emitted is directly proportional to the number of the atoms present if everything else is kept constant. The excitation to cause radiation can be supplied by flames or burning in an electric arc or spark. The sensitivity of the procedure is dependent upon the excitation energy or temperature to which the material is raised.

The traditional states of matter are: solid, liquid and gas. A fourth state of matter is said to exist called plasma or ionized gas. An ion is an electrically charged atom. An ionized gas has a much higher temperature than that gas in a normal state.

Theoretically, it is only necessary to introduce an aerosol of materials into an appropriate flame for some fraction of the material in solution to be converted into free atoms and their presence detected. However, for a variety of reasons the higher gas temperature provided by a plasma produces more sensitive results.

The inductively coupled plasma spectroscope utilizes argon gas converted into a plasma by induction from a high-frequency magnetic field. The sample of used lubricating oil needs only to be dissolved in xylene and aspirated into the center of the radiation (looks like a flame) of the ionized gas. The specific elements in the sample then emit their characteristic wave lengths of light, which can be separated spacially by a grating.

At this point it would be possible to introduce a photographic plate or film and determine the density of the individual wave lengths of light and, thus, the concentration of the specific element emitting light at that wave length. In such techniques, it is necessary to introduce an internal standard of known concentration to be burned simultaneously with the unknown. The system used in this instrument, however, uses photo multiplier tubes beyond the grating to convert the various wave lengths of light into electrical energy. That energy is then captured by a capacitor, which is discharged repeatedly at the appropriate time by computer control. The intensity of the charge is proportional to concentration. The multiple determinations are then compared by the computer to the concentration curve which was previously entered. Results are then printed by a teletype linked to the computer.

The former G. E. procedure, officially known as the "rotating platrode" method, could be considered Generation 1½. The new plasma system is about Generation 5. In the old method, a sample of used oil was coked on a platform electrode together with an internal standard. The rotating platform then formed one of the electrodes through which an arc was passed. The emissions from the various atoms present were passed through a quartz prism and ultimately recorded on a photographic plate. The density of the lines thus recorded were compared to the internal standard line and the concentration of the unknown element determined. This method required 45 minutes to 1 hour per sample to prepare, to run and to read. The inductively coupled plasma system requires approximately 3 minutes per sample. We have found that the results to date are more accurate than any preceding procedure we have used. It is too early at this time to report on comparative maintenance of the two instruments.

It is not intended to use the spark source for oil work. However, it can be so used. Presently this attachment is used for macro analysis of metals.

Tuesday, September 18, 1979

3:30 P.M.

REPORT OF THE COMMITTEE ON DIESEL MECHANICAL MAINTENANCE

Pre-Convention Presentation: Southern & Southwestern Railway Club, Inc.

April 19, 1979
Gault House
Louisville, KY

F. I. BURCHETT, Chairman
Mechanical Assistant-Locomotives
The Atchison, Topeka & Santa Fe Railway Co.
80 East Jackson Blvd.
Chicago, IL 60624

VICE CHAIRMAN

J. L. Kuhns, Assistant Superintendent Motive Power, Louisville & Nashville Railroad Co., P. O. Box 32290, Louisville, KY 40232

COMMITTEE MEMBERS

L. K. Adams, General Electric Company, Erie, PA 16531
W. W. Atkinson, Assistant to Chief Mechanical Officer, Southern Pacific Transp. Co., San Francisco, CA 94105
W. A. Brown, Assistant Manager Motive Power, Burlington Northern, Inc., St. Paul, MN 55101
L. M. Buffington, Assistant Superintendent Locomotive Shops, St. Louis-San Francisco Railway Co., Springfield, MO 65802
L. M. Daniel, Senior Mechanical Assistant-Motive Power, Canadian National Railways, Montreal, Quebec H3C 3N4
R. W. Diamond, Master Mechanic, Missouri Pacific Railroad, North Little Rock, AR 72116
E. M. Dobbels, Superintendent Motive Power, Chicago, Rock Island & Pacific Railroad, Chicago, IL 60604
M. M. Early, Mechanical Supervisor-Locomotive, Norfolk & Western Railway, Roanoke, VA 24011
A. A. Enders, Superintendent Motive Power, Chicago & North Western Transp. Co., Chicago, IL 60606
J. L. Gregory, Assistant Shop Manager, Southern Railway Co., Chattanooga, TN 37401
E. P. Heiler, Manager Locomotive Maintenance, Consolidated Rail Corp., Philadelphia, PA 19104
A. K. Jordan, Supervisor Diesel Engine Maintenance, Union Pacific Railroad Co., Omaha, NE 68179
J. M. Masterson, Locomotive Superintendent, Duluth, Missabe & Iron Range Railway Co., Proctor, MN 55810
C. D. Norris, Supervisor-Quality Control, Chessie System, Cumberland, MD 21502
R. T. Thetford, Superintendent Motive Power, Illinois Central Gulf Railroad, Chicago, IL 60601
L. F. Turney, Manager Technical Section, Electro-Motive Division, LaGrange, IL 60525

1979 TOPIC: "MAINTENANCE FOR HIGH RELIABILITY"

PERSONAL HISTORY

FRED I. BURCHETT

Chairman - L.M.O.A. Diesel Mechanical Committee, Fred began Santa Fe career as a Machinist Apprentice at La Junta, Colorado, 1941.

He was subsequently transferred to Chicago at 18th Street where he worked as a Diesel Repairman.

His career was interrupted when his "friends and neighbors" elected him to serve in the U. S. Navy in the South Pacific in World War II. He was discharged on October 10, 1945 at San Diego, California.

Fred returned to La Junta and back to Santa Fe, where he was employed as a Machinist until again transferred to Chicago's 21st Street Diesel Shop.

He was promoted to Assistant Supervisor of Diesel Engines and served in this capacity over the system until he was transferred from Chicago to Barstow as a Line Supervisor.

He was transferred to San Bernardino as Staff Assistant Supervisor of Diesel Engines, Assistant to the General Supervisor of Diesels.

He was transferred to Los Angeles, and subsequently to La Junta, Colorado as General Roundhouse Foreman.

His next move was to Albuquerque, New Mexico as General Locomotive Foreman. He also served as Acting Superintendent of Shops at this point.

He next transferred to San Bernardino as Assistant Superintendent of Shops. During this assignment, he participated in Santa Fe sponsored Institute of Business Economics and Management at the University of Los Angeles. He is also a graduate of Business Management at San Bernardino Valley College.

He was promoted to Acting Mechanical Superintendent and subsequently, to Superintendent of Shops at San Bernardino.

On March 1, 1972, he was again transferred to Chicago as Mechanical Assistant - Locomotives, on the staff of the Chief Mechanical Officer.

Fred looks forward with much anticipation to his next transfer from Chicago (into retirement)!!

I

WELDING CRANKSHAFTS

This topic is subject to many different opinions, as well as being very controversial.

Material prices are rising rapidly making it increasingly necessary for mechanical officers to do everything possible to salvage and reclaim locomotive material. Not only the price of material but the lead time for obtaining it are factors.

We have been reclaiming many engine parts such as pistons, liners, heads and crankshafts, by various means including welding heads and plating cylinder liners and crankshafts. It is safe to say that all railroads have experienced crankshaft failure owing to scoring. A thorough maintenance procedure will help control the scoring of crankshafts. With the approximate price of crankshafts as follows —

EMD 12 cylinder	$ 9,740.50
EMD 16 cylinder	15,950.00
G. E. 12 cylinder	16,524.00
G. E. 16 cylinder	19,300.00

any possible reclamation is to' our advantage. Crankshafts of 16 and 20 cylinder EMD engines are made in two halves, which can be replaced separately. However, 8 cylinder and 12 cylinder EMD engines and all classes of General Electric engines including 8 cylinder, 12 cylinder and 16 cylinder, have one-piece shafts. It has been our experience that main bearings are the predominant failure source on EMD crankshafts and rod bearing throws on the G. E. engines.

In most cases, whenever a General Electric engine has a rod bearing failure, the throw is scored beyond salvage by normal chrome plating. The throws are often worn down, .100 to .200 on a side, with thermal cracks going beyond those depths. Many such shafts could be salvaged by grinding the throw to remove all cracks and then welding the throw to bring it back to a standard size.

Crankshafts have been welded spasmatically over the last few years, primarily EMD. G.E. now is engaged in a research and test of welding of crankshafts. More and more railroads are entering a crankshaft reclamation program on their own. One railroad, for example, has four G.E.'s and one Alco crankshaft that have been welded. All told, there are approximately 40 to 60 EMD shafts and 20 G.E. shafts that have been welded, with EMD shafts operating up to five years.

G.E. has been testing for approximately two years. Some of those shafts have failed. However, none of the shaft failures to date were associated with the welding process. Owing to the severe quality control problem associated with this type of reclamation, G.E. is writing a reclamation specification with monitoring facilities to insure a quality repair.

Seven full size crankshafts and many more journal sections have undergone overlay weld deposition. In the process, at least two layers of weld is placed on the journal surface. When this is done and the interpass temperature is maintained, the second layer tempers the first layer. By maintaining approximately 500° F. preheat and interpass temperatures, no stress relieving is found to be necessary. Metallurgical examination at the weld deposits and at the heat affected zone has yielded very low hardness value, thus indicating no need for a stress relieving anneal.

To prevent ruining an induction hardened crankshaft, post heat has to be limited to below 750° F. If this temperature is exceeded, the hardness of the induction hardened journal surfaces will be reduced. While holding a shaft at 750° F.

for long periods of time will benefit stresswise, a 1,100° F. temperature soak for several hours is required for a full anneal. The greatest attention has been placed on reclaiming a shaft with .080-in. radial overlay buildup. The maximum radial buildup in G.E.'s experience is .150-in. Studies have indicated that about 80 percent of all crankshafts could be repaired at the .100-in. value. The maximum overlay buildup value has not been determined experimentally. However, a .250-in. radial buildup is viewed as an upper limit.

The crankshafts operating on one railroad were ground down radially from .200-in. to .300 in. to remove all traces of cracks and then re-magnafluxed to determine if all cracks had been removed.

After that procedure, they were placed in an oven to heat at approximately 450° F. for ten hours and then removed and placed in the welder, which is a submerge arc welding process, and bad journals were welded to an oversize. The welding machine is set to approximately 180 amps and about 30 volts for that process. Two passes were made to bring the journal up to an oversize. After welding is completed, the crankshafts are replaced in the oven and heated at 750° F. for ten hours for stress relieving.

Next, the shaft is allowed to cool at a slow rate to room temperature. The shaft is then preground to approximately .010-in. to .015-in. undersize in preparation for chrome plating. The entire shaft is again magnafluxed for cracks. If no cracks are found, the shafts are given normal chrome plating.

A Lincoln 760 rod is used on nitrate hardened shafts, and a Lincoln 780 on induction hardened shafts.

Seven railroads are known to be experimenting with welded crankshafts, five being represented on this committee. We believe that welded crankshafts will be a recognized standard procedure in the future.

This is a limited amount of information on this subject, but as time goes by more information will be available. Quality control will be the main factor determining the success of this kind of reclamation.

Presently, two other companies are active in this reclamation, Chrome Crankshaft and Precision National. There may be others unknown to this committee.

II
GENERAL ELECTRIC POWER ASSEMBLIES

The following discussion is limited to the liner, piston, head and jacket. These components will be discussed under four categories as follows:

1. Leading causes for renewal of assemblies;

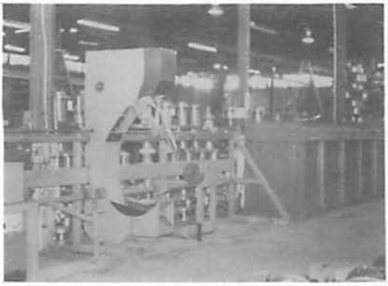


FIG. 1

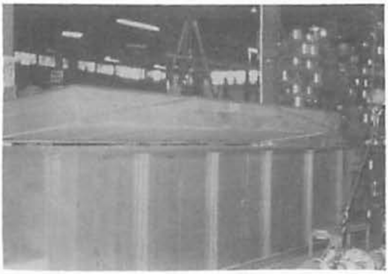


FIG. 2


FIG. 3

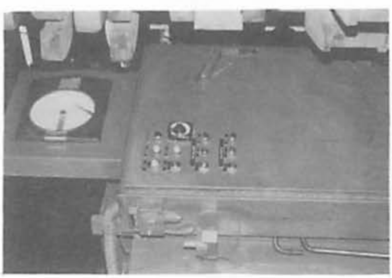


FIG. 4

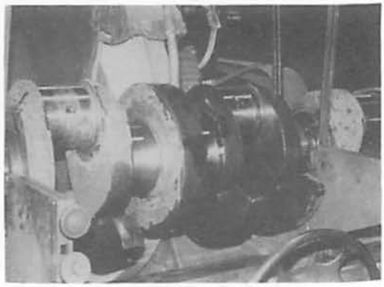


FIG. 5

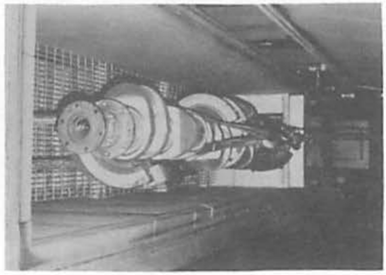


FIG. 6

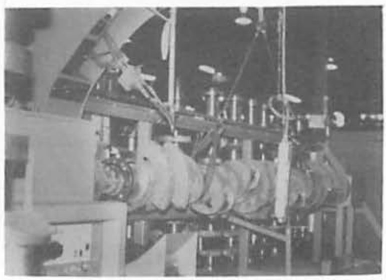


FIG. 7

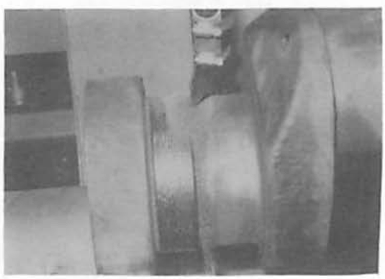


FIG. 8

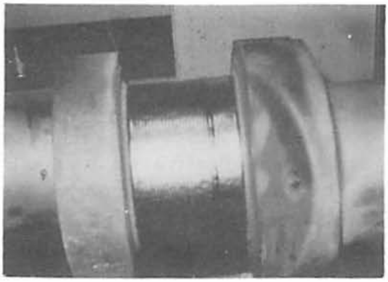


FIG. 9

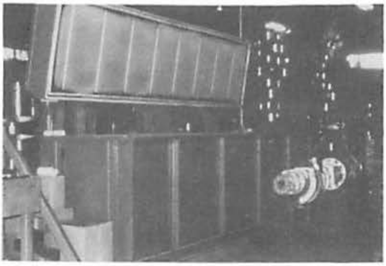


FIG. 10

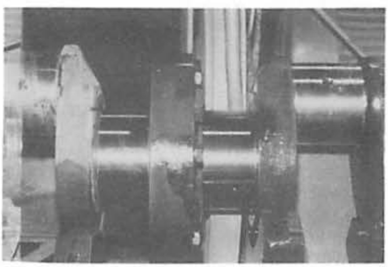


FIG. 11

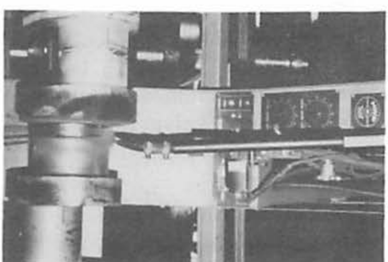


FIG. 12

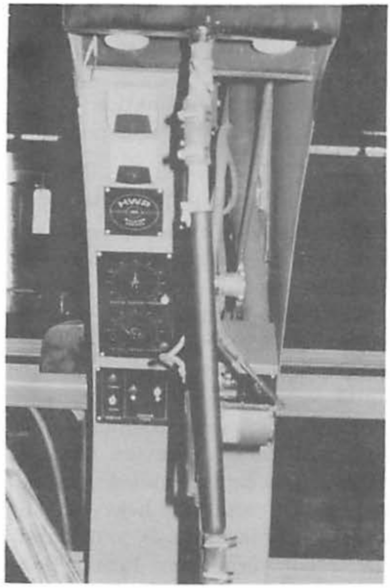


FIG. 13

FIG. 14

2. Methods of diagnosing problems leading to assembly replacement.
3. Component reclamation;
4. Application of new or reclaimed components.

CAUSES FOR RENEWAL

A recap of a member railroad's backshop assembly teardown inspection records indicates an annual replacement rate of over 30 percent. This road has a G.E. locomotive fleet in excess of 400 units equipped with 16 cylinder engines, or approximately 7000 G.E. cylinders in service. A total of 2300 power assemblies were reworked through the heavy repair shop for both failures and classified repair programs during 1978. The total number of defects identified exceeds the total number of assemblies handled because numerous assemblies had more than one defect.

G.E. Power Assembly Rework Data 1978

Total assemblies reworked	2310
Component Defect	**Totals**
Liner to cylinder head gasket	1090
Lower head to jacket seal	955
Water discharge seal	206
Lower liner seal	776
Bent valves	144
Broken valves	181
Scored liners	405
Worn liners	116
Cracked head	69
Broken or cracked jacket	16
Broken clamp ring bolts	367
Defective pistons and/or rings	49

The above data clearly reveals that seal defects, with resulting water or compression leaks, can be the major cause for assembly overhaul on this railroad, followed by cylinder scoring and valve defects.

We believe that the loss of the lower head to jacket seal "shoulder gasket" is indicative of overheating of the power assembly. We believe the liner to cylinder head gasket can and does fail without loss of the "shoulder gasket." However, the reverse is not true; overheating causes the loss of the shoulder gasket and usually the silicone gasket backing up the flexitallic fire gasket.

Another member railroad with a G.E. fleet of 295 locomotives replaced 529 power assemblies over a six-month period for the following reasons, as reported by maintenance forces:

Component Defect	Total
Engine failures	6
Water leaks	146
Broken rings	7
Smooth rings	1
Valve blow	5
Broken valve	34
Broken piston	17
Scored liners	13
Blow-by	81
Bent rod	38
Cracked liner	5
Lower liner seal	58
Turbo failures	61
Miscellaneous	124

The above data indicates the major cause of defects to be seal and water leaks followed by blow-by, scoring and valve failure.

G.E. maintains records of power assembly failures on original equipment warranty failures. The following failure data is for selected failure modes of power assemblies on 396 G.E. New Series

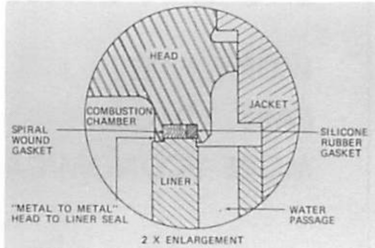
locomotives with an average age span from one month to 24 months:

Water leaks	0.124%
Broken valves	0.090%
Valve blow	0.054%
Scored liner	0.018%

The majority of water leaks in the cylinder area are at the top or bottom liner seal areas.

The top seal is a Flexitallic gasket and a silicone rubber gasket. Considerable improvements have been made over the years in this area, particularly on the Flexitallic gasket. The Flexitallic gasket must provide perfect sealing against the combustion gases to prevent deterioration of the silicone square-cut water seal by hot gases. The most recent improvement was a Monel-filled (instead of copper-filled) Flexitallic gasket. The change was made to eliminate the oxidation of copper filler particularly affected by high-sulphur fuel.

The cylinder lower liner seal arrangement has two Buna-N "O" ring seals. The lower liner seal is a round "O" ring and the clamp ring seal is a square cut "O" ring. The square cut "O" ring now made by Viton, instead of Buna-N, is held in place by a steel back-up ring. This has been improved just recently. The new back-up ring has been modified by reducing the width of the clamp ring bolt hole slots to improve support of the square cut "O" ring. The clamp ring bolt will be changed to a 180,-



HEAD TO LINER UPPER LINER SEAL ARRANGEMENT

FIG. 1

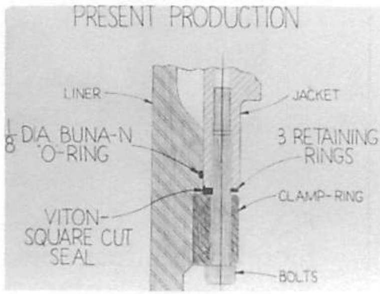


FIG. 2-A

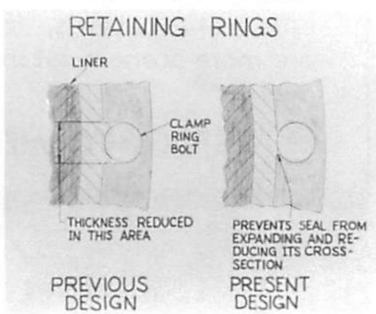


FIG. 2-B

000 psi bolt with the thread rolled after heat treatment instead of a 140,000 psi bolt thread rolled before heat treatment.

Over the years, G.E., as well as the railroads, has worked toward improvements to overcome the water seal problem that is the predominant cause of assembly defects. The latest innovations are machining of a second seal groove at the lower liner seal area, and electron beam welding of the liner and head to form a single unit. These items will be discussed further in the reclamation portion of this report.

MEANS OR METHODS OF DIAGNOSING PROBLEMS

Many power assemblies arriving at heavy repair shops, upon teardown, have been found to be in serviceable condition, indicating

ENGINE SHUT-DOWNS

Item	Cause	Low Oil Pressure (LOP)	Low Water Pressure (LWP)	Crankcase Over-Pressure (COP)	Engine Over-Speed (O/S)	Fuel Problem (FUEL)
1	Low oil level	X				
2	Blocked oil pan strainer	X				
3	Cover off oil pan strainer or defective cover gasket	X				
4	Filter drain back valve (C) open	X				
5	Dynamic braking for long period and at high ambient temperature	X				
6	Plugged lube-oil cooler (oil side)	X				
7	Plugged lube-oil cooler (water side)		X			
8	Low water level		X			
9	Water-tank fill cap missing or loose fit		X			
10	Water storage tank: defective baffle or splitter, blocked screens, cracks in tank		X			
11	Hot water (causes hot and low viscosity oil)	X				
12	Relief valve set too low	X				
13	Low lube-oil viscosity (fuel dilution)	X				
14	Bonded-rubber pump drive sheared	X	X			
15	Plugged fuel filter	X	X			
16	Plugged engine air filters	X	X			
17	Engine bog due to sticky fuel linkage	X	X			
18	Engine bog due to faulty electrical control (load timing panel, rate card, T1, EC11, or EC12, shorted PT1)	X	X			
19	Pipe plug missing from cavity in top of forward-end cover	X		X		
20	Crankcase breather screen inverted (large mesh up)			X		
21	Stuck rings or scored liners			X		
22	Lube-oil level too high			X		
23	Blocked breather pipe at the exhaust stack			X		
24	Dry piston rings (after extended shutdown)			X		
25	Air blow down (at lube-oil filter change)			X		
26	Wrong lube-oil dipstick	X		X		
27	Cracked piston crown			X		
28	Faulty COP switch			X		
29	Wrong piston rings applied-probably filled iron rings in tufftrided liner-rapid wear then excessive blow-by			X		
30	Engine overspeed (true overspeed)				X	
31	False engine overspeed (cover or adjustment screw loose)				X	
32	Fuel-injection-pump rack or fuel linkage stuck	X	X		X	
33	Faulty overspeed governor				X	
34	Leak in oil line between O/S governor & link				X	
35	Fuel tank empty					X
36	Excessive leakage in fuel suction line or in seal of fuel transfer pump	X	X			X
37	Ice in fuel tank or fuel strainer					X
38	Faulty governor	X	X			
39	Plugged lube-oil filter	X				

FIG. 2-C

maintenance personnel unnecessarily replaced the assembly to correct an engine operating problem. Obviously, when this occurs, personnel performing this work haven't properly diagnosed the true cause of the engine problem.

This chart identifies some of the problems or engine conditions confronting maintenance personnel and the probable cause of the difficulty.

The committee offers these comments relative to diagnosing and correcting the preceding, as well as other engine malfunctions attributed to power assemblies.

A. Low Oil Pressure

Lube oil diluted to the extent of causing governor shutdown can be detected by means of checking lube oil level, flash testing of lube oil and lab analysis of oil. Flash testing of the lube oil may not be a reliable method of checking lube oil viscosity. The variation in this test could allow an oil to be used that is below 5 percent dilution, or to be dumped that has satisfactory viscosity.

If available, the committee strongly recommends a scheduled routine of lab analysis of lube oil. One member road as a means of accomplishing programmed oil sampling has developed its Rule 203 inspection card to indicate to maintenance personnel when samples are due.

Once lube oil has been found to be diluted, an inspection of the engine should be performed to correct the leak. If the engine is running, listen for unusual pounding at each cylinder. "Pop" test each cylinder by increasing injection pump rack 2 or 3 mm; the resulting sharp ping qualifies the pump and nozzle. "A mushy" explosion indicates defective pump nozzle or other problem preventing proper firing of the cylinder. The pump adjusting cover should be opened to insure proper flow of return fuel. The nozzle and associated piping should be inspected for leaks in the cylinder overhead.

A very important item that can cause fuel dilution is running the engine cold at idle. The viscosity of the oil drops rapidly when the water temperatures are below 150° F. We recommend inspection and replacement of thermostats or flow control valve pellet, if the temperature is found to be below 150° F. at idle.

Remove crankcase inspection covers and make an inspection of exposed components. Bar engine to raise and lower pistons to check for scored cylinders and scored piston skirts. Further inspection can be performed by removing nozzles and inspecting for scored cylinders with a boroscope.

B. Low Water Pressure

Loss of engine coolant caused by assembly leaking can be determined by several methods:

1. Detecting lower liner seal leaks.
   a. Blank water tank fill cap to prevent loss of pressure and blank off the water pump.

b. Connect a regulated water supply to maintain 20 psi on cooling system.

c. Perform crankcase inspection; look carefully below each cylinder.

Several railroads use this method in their scheduled maintenance program to inspect all components of the cooling system for leaks.

2. Detecting upper and lower liner seal leaks.

   a. Drain cooling system.

   b. Disconnect cooling system from engine at water pump inlet, discharge header above right intercooler, cab heater supply and any other external water connections.

   c. Fill engine with water and purge all trapped air.

   d. Apply 50 psi and inspect for leakage below each cylinder. Remove nozzles and with a boroscope inspect for leakage into combustion chamber.

3. Detecting top liner seal leaks.

   a. Remove compression elbows at water discharge header. Leave water connections to cylinders in place.

   b. Fill cooling system so water level is to top of water connections at each cylinder.

   c. Pull low oil button on governor to prevent engine from firing during test.

   d. Crank engine and observe each water connection. A cylinder with defective top seal will blow water out of its water connection.

C. Crankcase Overpressure

Activation of the COP device can be initiated by several reasons as the shutdown chart indicates.

Defective pistons, rings or liners have been identified as a major contributor to this problem.

The committee recommends that the following procedures be observed for inspection to determine defective cylinders initiating crankcase overpressure:

Engine Running

a. Check lube oil level.

b. Pop test each injector as previously described.

c. Connect a water manometer to a crankcase inspection cover fitted with a tube connector, or there is a fitting with a ⅛-in. pipe plug for Allen wrench socket in the lower flange, just below the crankcase overpressure switch. Run engine at full load throttle 8 (providing engine protector doesn't trip) and observe reading on manometer. Readings should indicate negative pressure. This test will qualify the COP device.

d. Observe color of exhaust gas. A blue cast indicates excessive lube oil in the exhaust gas resulting from possible faulty rings or scored liners.

e. If all other causes for overpressure have been checked and/or qualified and a cylinder is suspected of causing COP, the engine should be inspected as follows: Perform crankcase inspection including piston skirt and liner inspection for scoring as previously outlined. If no defects are located by this inspection, there are three methods available that can successfully isolate a faulty cylinder.

Test "A"

Position piston within two degrees of firing top dead center position. Remove compression relief valve and connect an air hose to the release adaptor. CAUTION — Engine may roll over during next test.

Apply 100 psi to the cylinder and listen for leakage to crankcase, air manifold and exhaust stack.

Repeat test for each cylinder.

Test "B"

Apply an air hose to cylinder being tested in a similar manner as Test A.

In the air supply line, install a pressure regulator set at 40-50 psi and a flow meter. (A brake pipe flow indicator can be used.) Apply air to cylinder and record flow value.

Repeat test for each cylinder. Cylinders exhibiting higher than average flow rate may have defective rings, valves or liners. One railroad has developed this test using a modified nozzle to feed air to the cylinder. A reading of 4 on the gauge has been set as their limit for condemning an assembly.

Test "C"

Prevent engine from firing during cranking by pulling low oil button to tripped position or latch shut down relay. Remove compression release valves from each cylinder.

Apply compression gauges to each cylinder and rotate engine. Cylinders exhibiting lower than average compression pressure may have defective pistons, liners or rings.

Prior to removal of a cylinder that has failed to qualify one or more of the preceding tests, the committee recommends boroscope of cylinder.

D. Excessive Exhaust Smoke

Again we will disregard other causes such as defective turbo, plugged air filters, etc., and attempt to identify power assembly problems that can cause excessive exhaust smoke.

Intermittent smoke or "puffing" usually indicates one or more cylinders not firing properly. The "pop" test method is recommended as the most rapid means of isolating a misfiring cylinder.

Cylinders found exhibiting a "mushy" explosion may have defective nozzle pump, improperly timed pump, bent rod, etc. If replacement of pump and nozzle and proper timing fail to correct the condition, further inspection for scoring, defective piston, etc. should be performed.

Continuous black smoking may be caused by excessive carbon build-up in the air inlet ports. Engines found with carbon depth in excess of ¼-in. should be cleaned by blasting with ground walnut shells and an inlet port cleaner. Continuous operation in this mode can cause turbocharger damage from surging. This condition is usually the result of excessive idling or light load operation.

E. Valve Blow

This condition is usually very apparent by the noise of the engine exhaust. Locating or isolating the defective cylinder can again be accomplished by pop testing (if engine running) or compression test methods.

Valve failure can create further costly turbo repairs owing to possibility of foreign objects striking the turbine wheel. The committee recommends when a cylinder is removed for valve blow (or other component break up failures) that the entire exhaust system downstream from the affected assembly be cleaned and inspected for foreign material. Usually this inspection and cleaning can be accomplished by removal of exhaust elbows at each cylinder or by removal of plugs at end of manifold.

Valve tappet clearances should be checked at six-month intervals and overhead inspections included in your scheduled maintenance program. This can reduce incidents of valve failures.

COMPONENT RECLAMATION

Rework of Cylinders

Railroads currently involved in unit exchange or in-house assembly reclamation should consider component usage, equipment, shop space and personnel expense prior to a conversion from their present program.

A step by step detailed outline of assembly component rebuild would be repetitive of data available in G.E. publications; therefore, the committee recommends the following as a general guide to railroads involved in their own reclamation program:

1. Convert to 15 degree inlet valve configuration. This process requires purchase of new valves and regrinding of head seats.
2. Valve rotators should be installed on all reworked assemblies.
3. New tuftrided valve guides should be installed on each reworked head. This varies from G. E. recommendations. One railroad reported difficulty during seat grinding process obtaining correct seat concentricity. The problem was overcome by 100 percent use of new guides.

General Electric now is field testing two large (.275 dia. versus the one presently used .139 dia.) "O" ring at lower jacket to liner seal area — one made of Ethylene Propylene on the water side and one made of Viton. Twenty-four units were shipped with this configuration in 1978 and 60 more engines are scheduled this way for 1979. Owing to reported incidents of cracking of the lower "O" ring land, G.E. is currently considering changes in the lower "O" ring groove modification. Specifications are as yet unavailable.

Some member roads are reworking liners by retaining original design of the lower "O" ring seal groove and machining a second groove 11/32-in. above existing 1/8-in. groove. G.E. also is field testing welded head to liner assemblies, which eliminate gasketing. This is one of the programs that Engine Engineering is working on to eliminate top liner seal leaks. The liner on the welded head to liner assemblies is steel, rather than cast iron. All testing so far has been successful, with no major problems occurring. They are testing 144 cylinders on seven railroads. Insufficient test data is available to recommend retrofit to either design at this time; however, they appear to be most promising in overcoming sealing problems.

APPLICATION OF NEW OR RECLAIMED COMPONENTS CYLINDER REMOVAL

Cylinders may be removed either with or without their respective pistons and connecting rods, depending on the nature of work to be performed. Cooling water must be drained before cylinder removal. Lube oil should be drained if extensive work is to be performed, to guard against contamination of the oil.

NOTE: When removing cylinders for changing out piston rings at their regular change period, apply reconditioned cylinder assemblies.

To remove a cylinder, proceed as follows:

1. Disconnect and remove the following parts from the cylinder:
   a. Cylinder covers
   b. Fuel-header lines at flexible hose couplings. Cap the lines and the pump inlet connections to keep the dirt out.
   c. Water inlet and discharge headers. Loosen the compression couplings and remove the bolts from the flanges. Remove the upper water connections and compression elbow.
   d. Exhaust manifold at the cylinder flange.
   e. Air intake manifold, by unbolting the clamp rings and slipping the tube sections free of the intake manifold sections.
   f. Fuel-rack vertical link. Remove the self-locking nut and bolt from the upper fuel linkage lever bearing.
2. Bar-over the crankshaft until the piston in the cylinder to be removed is near top dead center with all valves closed.
3. Remove the short crossover push rod, and then the two vertical push rods. Use the rocker arm depressor (Part 147X1040-1) to rotate the rocker arms for necessary end

clearance. Do not bend the push rods by excessive prying or forcing. The fuel-pump push-rod assembly will be removed with the cylinder.

4. Remove the four cylinder-mounting bolts, using power-wrench arrangement (Part 147X1568) as shown in Fig. 3, or an impact wrench (Part 147X1684).

CAUTION: If it should be necessary to apply heat to the bolt head to facilitate removal, replace the bolt, because heat changes the tensile strength of the bolt.

NOTE: If the connecting rod and piston are to be removed with the cylinder assembly, proceed as follows:

   a. To hold the piston assembly in the cylinder, apply the piston retainer (Part 147X-1406-1) as shown in Fig. 4.

   b. If an articulated rod is to be removed, remove the articulated rod pin bolts.

   c. If a master rod is to be removed, disconnect the articulated rod and remove the master-rod bearing cap. Push the articulated rod and piston up in the cylinder and secure the rod with wire to the camshaft to provide working room. Use suitable protection with the master rod to avoid damage to other parts during removal.

5. Attach the cylinder lifter (Part 147X1606) over the water discharge opening on the back of the cylinder, as shown in Fig. 5 Use only the high-strength bolts supplied with the lifting tool. Be sure they are tight.

6. After making sure the cylinder has been completely disconnected, carefully lift the cylinder, guiding it during removal. If the piston and connecting rod are not removed with the cylinder, open the cylinder compression release plug. Protect the piston from damage, which would be caused by its falling and scuffing against the engine frame as the cylinder is lifted off. Apply the piston guide (Part 147X1091-1) to protect and guide the piston when the crankshaft is rotated with cylinders removed.

CAUTION: If pistons and rods are not properly supported when cylinders are removed, in certain positions of the crankshaft, the articulated connecting rods can contact and damage the articulating pin bushing.

NOTE: If desirable, with the cylinder removed, the piston may be detached and removed while the rod remains in the engine.

Whenever a cylinder assembly is removed from an engine, the "O" rings on the crosshead guides should be renewed.

CYLINDER INSTALLATION

A. Mounting Cylinder

NOTE: When installing a cylinder assembly with the steel head insert to a main frame previously utilizing the cylinder assembly with the cast-in head, the depth of the cylinder bore in the main frame should be checked. The location of the clamp ring on cylinder assemblies with the steel head inserts requires that the cylinder bore diameter be maintained to a depth of 4½ in. This can be checked with a combination square set to 4½ in. Position the square around the cylinder bore to indicate this depth. Any interference within the 4½ in. depth should be ground away. This has sometimes occurred at the stud bosses and/or the crosshead guide bosses.

CAUTION: Care must be exercised to prevent the abrasive grinding dust from entering the crankcase, crosshead guides, or other exposed working areas of the engine.

A cylinder may be installed either with its piston and connecting rod assembly or separately. The general procedure is the same in either case. Proceed as follows:

1. Make sure the piston and rings are in good condition. Recommend the use of new rings.

CAUTION: **Do not** use chrome rings with chrome liners. **Do not** use iron rings in Tufftrided liners. Refer to your Renewal Parts Catalog for the proper ring and liner combinations.

2. Properly stagger the ring end gaps around the piston. Coat

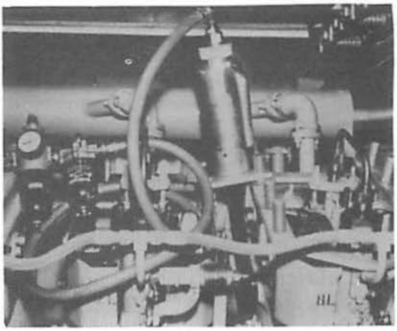


FIG. 3

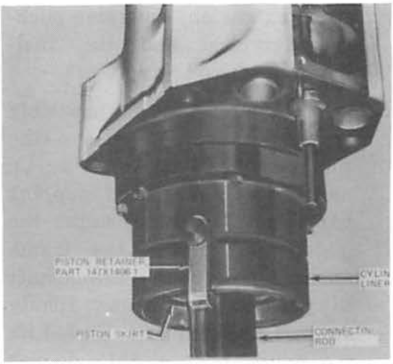


FIG. 4

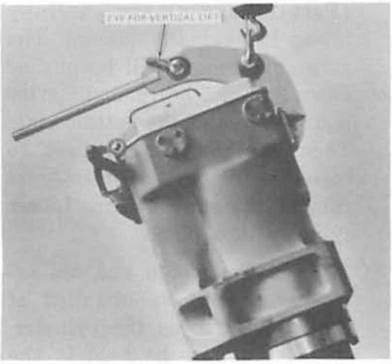


FIG. 5

the piston with a liberal quantity of clean engine lube oil. Apply the ring compressor (Part 147X1089).

3. Back out all four valve-tappet adjusting screws to provide maximum clearance between the tappet buttons and the valve stems. Adjust the fuel-pump tappet rod to its minimum length.
4. Lubricate with Lubriplate Spray Lube "A" (*Part 147X-1614), and apply new "O" rings to the radius at the lower cylinder extension, the valve push-rod ferrules, and the fuel-pump push-rod guide.
5. If the piston and rod assembly is in the engine, remove the piston guide (Part 147X1091-1), and insert the piston support bar (Part 147X1090) under the piston and across the frame opening. Turn the crankshaft to position the piston firmly against the support bar. Lift the cylinder at a 22½ degree angle, using the cylinder lifter (Part 147X1606) and carefully lower it over the piston. The ring compressor will be pushed down and can be removed after it drops free of the bottom ring. Then, turn the crankshaft to raise the piston sufficiently to remove the support bar. Lower cylinder into place.

NOTE: If the piston and rod assembly are to be installed at the same time as the cylinder, the piston may be held in the cylinder by using the piston retainer shown in Fig 4. Install the left-bank cylinders with the master rods first, followed by the right bank cylinders with the articulated rods. Use suitable protection with the master rod to avoid damage to other parts. Complete the installation of connecting rods.

6. Coat the cylinder mounting-bolt threads and washer face with Lubriplate 630-AA (Part 147X-2163). Install the bolts finger-tight.
7. Tighten the cylinder mounting bolts EVENLY to the torque specified in the DATA Section.
8. Connect the air intake and exhaust manifolds, and the water headers, using new gaskets. Install and connect the fuel header lines.
9. Connect the injection-pump-rack vertical link. Check pump-rack travel as described in FUEL PUMP RACK SETTING instructions in Section DE-8, and adjust as necessary.

B. Inserting Push Rods

To obtain sufficient clearance when installing push rods, each valve crosshead roller must be off the high portion of its cam. With the rollers on the base circle of the cams, proceed as follows:

1. Insert the vertical push rods into their sockets in the crossheads; then, install the short crossover push rod.
2. Rotate the rocker arms, using the rocker-arm depressor (Part 147X1040-1), until the push

rods can be inserted into their respective rocker-arm sockets.

C. Adjusting Tappet Clearance & Pump Timing

Valve tappet clearance and fuel-pump timing can both be accomplished at the same positioning of the piston in the cylinder. Proceed as follows:

1. Properly position the piston in the cylinder using one of the following methods.
   a. On older engines having timing marks on the barring-over hub at the forward (free) end of the engine, rotate the crankshaft until the SET mark for the cylinder being worked on is exactly aligned with the pointer for the bank containing that cylinder. Check that both inlet and exhaust valves are closed, indicating that the piston is on the compression stroke.

NOTE: While two cylinder numbers are shown adjacent to each SET mark, only the cylinder with piston approaching top center on the compression stroke may be set. The piston in the other cylinder is on the exhaust stroke, and the crankshaft must be turned through one complete revolution to bring the piston in this second cylinder onto the compression stroke before the valves and fuel pump can be set.

   b. On newer engines having barring-over governor drive, remove the timing-window cover and the barring-over cover from the governor drive. Move the barring-over gear inward into engagement with the camshaft gear, then apply either a 1-in. ratchet wrench or an air-operated wrench to the barring-over gear. Rotate the camshaft until the correct timing (degree) mark for the cylinder being worked on, as specified on the timing nameplate, is exactly aligned with the pointer. Check that both inlet and exhaust valves are closed, indicating that the piston is on the compression stroke.

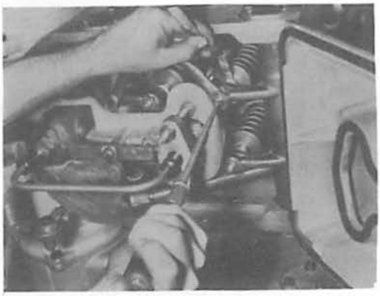


FIG. 6

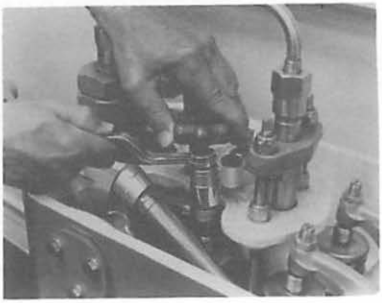


FIG. 7

2. Using standard tools as shown in Fig. 6 or the special tool (Part 147X1042) shown in Fig. 7, loosen the tappet locknut and adjust clearances to:
   Exhaust valve 0.028 - 0.030"
   Intake valve 0.018 - 0.020"
   Tighten the locknut to the value specified in the DATA section and re-check the clearance. Continue until all valve tappets have been properly adjusted.

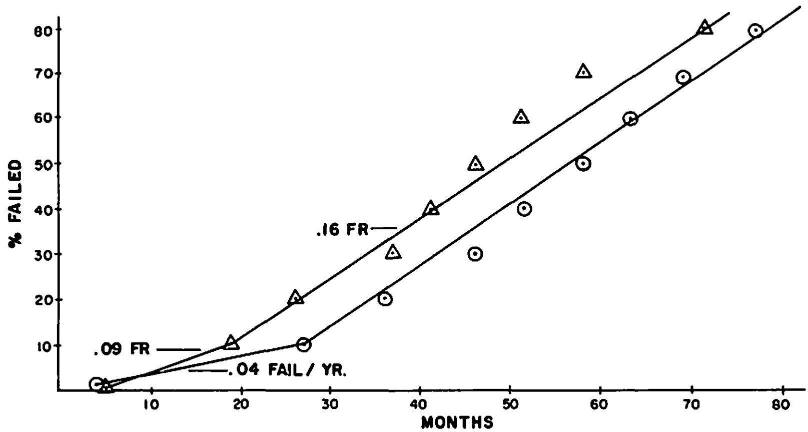
3. Check the fuel-injection pump timing and adjust as necessary.

When using the "Pneutorque" wrench, set the regulator with motor running unloaded at 43 psi (296 kPa) to achieve this torque value when removing these bolts, set the regulator to 65 to 80 psi (448 to 552 kPa); after removing bolts, reset the regulator to 43 psi to avoid accidental tightening (and excessive stretching) of cylinder hold-down bolts.

ORIGINAL EQUIPMENT POWER ASSEMBLY

The graph represents a comparison of two model years of U33 original power assemblies. All units of the U33 model fleet built in these years were included in the sample. The two-step curve represents the early random failures and the normal wear-out rate

TORQUE VALUES	Lb - Ft	N - m
Liner clamping-ring bolts		
At assembly, jacket hot (method "A")	85-90	115-122
At retorque, jacket cool (method "A")	70-75	95-102
At assembly, jacket hot (method "B")	85-90	115-122
At retorque, jacket cool (method "B")	95-100	129-136
Rocker-shaft end-plate bolts	30-35	41-47
Nozzle clamping bar studs	55-60	75-81
Thread inserts, in main frame, for cylinder mounting bolts	375-400	508-542
*Bolts, cylinder hold-down	1300-1400	1762-1898
Bolts, fuel injection pump mounting	45-50	61-68
Nuts, fuel injector nozzle mounting	30-35	41-47
Fittings, to fuel injection pump inlet	90-100	122-136
Hoses, to curved fuel-inlet tee	30-35	41-47
Nuts, high-pressure fuel line, large fuel system	140-150	190-203
Nuts, high-pressure fuel line, small fuel system	65-70	88-95
Bolts, exhaust manifold to cylinder mounting	100-110	136-149
Nuts, water inlet and water discharge compression coupling	20-25	27-34
Adapter, compression release	60-65	81-88
Set screws, compression release (new style)	15-20	20-27
Plug, compression release	20-25	27-34
Locknuts, valve tappet screw	50-55	68-75



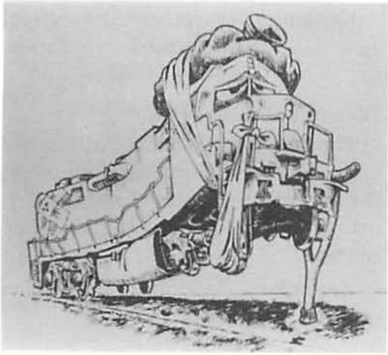
U33 ORIGINAL POWER ASSEMBLIES

of the component. The similar wear curves — 16 percent failures/year — indicate that after random failures both years exhibited same wear characteristics. Initial failures occurred approximately the same time (4-5 months). The difference of the random failure rate — 9 percent failures/year for 1973 models vs. 4 percent failures/year for 1972 models — indicates that a degradation of quality, design or material change occurred between 1972 and 1973. This difference caused an approximate one-year shift in the start of the wear rates.

Graphing data in this way provides a good tool in determining component life and possible component changeout schedules. Ideally, consideration for scheduled changeout would be given to the end of the ramdom failure rate. Cost trade-offs would need to be developed for changeout further up the wear curve. Unscheduled failures will increase in proportion to increased deferrence of scheduled changeout.

III
ASSIGNED MAINTENANCE TERMINALS — A MEANS OF PLACING MAINTENANCE RESPONSIBILITY

In a recent survey, used to develop this portion of the paper, the majority of responding members were found to have assigned



maintenance. Not only did those roads feel that assigned maintenance was an excellent means of placing responsibility, but that it provided many other benefits.

On the positive side, managers felt that assigned maintenance provided a detailed way to place responsibility, control manpower, give greater availability and control of material, control budgets, increase efficiency, reduce facilities and promote pride in workmanship. Negative comments primarily were directed toward situations that were out of Mechanical Department control. The two outstanding remarks were: Operations not returning units to "Home" point on time, and units being hauled "Dead In Train" for maintenance. The other most referred to was a disregard by maintenance forces for non-assigned units. With this feedback, as the pros and and cons indicate, assigned maintenance is the best approach to a good preventative maintenance program.

In establishing responsibility, one must first have a method for measuring performance. By the response received, reliability is the measure most used. This is because reliability, or lack of it, is the subject of most discussions by Operating Department personnel. When reliability falters, most Mechanical Managers receive a great deal of criticism. Reliability is determined by what the Mechanical Department refers to as "Line of Road Failures" Line of road failures reduce availability, lead to increased, unscheduled shoppings and excessive shop loads.

It is evident by the response received that all roads use failures as a unit measure and document these occurrences as they happen. To show that this can be put to productive use, a formula produced by one member road for measuring the performance of its shops will be used as an example. Failures are a key part of this formula and require documentation of all reported malfunctions.

Three elements are used in the preparation of this formula, which is called an "Efficiency Rating." These three elements are locomotive bad order, control inspection failures and dispatch failures. Each will be described in detail and how they are put together to arrive at the Efficiency Rating.

Locomotive Bad Order

This is where the number of assigned units held for repairs are divided by the total assigned units to that shop to arrive at a bad order percentage. (Units held are counted once each 24 hours at the same time of the day.)

Example: 300 units assigned—
30 units held
30/300=
10 percent bad order

Control Inspection Failures

The number of units failing on line of road within 30 days or less of a control inspection made by that shop, divided by the total number of control inspections performed equals the control inspection failure percentage. (Control inspections are performed on a quarterly basis.)

Example: 28 control inspections performed — 4 failed
4/28=14.3%

Dispatch Failures

The number of units failing out of a dispatch point is divided by the number of units dispatched to determine dispatch failure percentage.

Example: 1400 units dispatched —28 failed
28/1400=2.0%

The three percentages from those calculations are now put together to form the EFFICIENCY RATING in this manner:

$$100 - \frac{(\text{Bad Order} + \text{Controlled Inspection Failures} + \text{Dispatched Failures})}{3} \div .95 = \text{Efficiency Rating}$$

The division of .95 is used to reflect an arbitrary, assuming that 95 percent is actually 100 percent performance. Using the percentages from the calculations, they are now put together to form the EFFICIENCY RATING in this manner:

$$100 - \frac{(10.0 + 14.3 + 2.0)}{3} \div .95 = 96.0\%$$

EFFICIENCY PERCENTAGE

B/O = 10.0% C.I.F. = 14.3% D.F. = 2.0%

$$100 - \frac{(10.0 + 14.3 + 2.0)}{3} \div .95 = \text{E.P.}$$

$$100 - \frac{(26.3)}{3} \div .95 = \text{E.P.}$$

$$100 - 8.77 \div .95 = \text{E.P.}$$

$$91.23 \div .95 = \text{E.P.}$$

96.0% EFFICIENCY

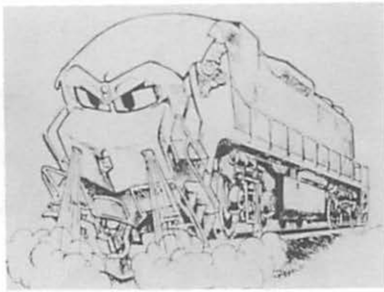
The formula shown at first seems very complex and time consuming. However, the base information is in all probability available to you now. On the example road all information except for number of units dispatched was already available in computer storage. The only additional time required was one hour at the end of each month to compile existing data into the efficiency rating.

Results generated by the competitive spirit of pitting one shop against another using the efficiency rating has provided exceptional results to the Mechanical Department and railroad. This is reflected in the following figures:

	Average Failures per day	Availability Percentage
1976	12.0	87.2%
1977	11.4	87.1%
1978	9.9	90.1%

We don't want to leave you with the impression that this rating alone improved availability and reduced failures. This method of generating interest and assigned maintenance has been an important factor. Coupled with this has been a training program initiated for craftsmen and apprentices that has increased quality and efficiency. The efficiency rating is always a subject of conversation in all classrooms. Interest generated by this method has involved the rank and file employees involved in the condition of assigned units as well as heightening supervisor enthusiasm.

In summary, this committee feels that assigned maintenance terminals are a must to provide a means of placing direct maintenance responsibility.



IV
RADIATORS

Radiators are not considered a major expense. However, they can either directly or indirectly cause railroads a lot of expensive repairs. Line of road failures cause needless delays, which indirectly cause out-of-pocket expense and per diem losses as well as premature power assembly failures or premature complete engine failures.

We know the importance of keeping a diesel engine operating within its proper temperature range. Following is a brief history of radiators, cause of their failure, and improvements and possible corrective action to be taken.

The older-type locomotives, F-7, GP-7, switch engines and so forth, used four-in. radiators and operated at lower pressures. Those radiators gave very little trouble. In fact, many railroads are still using many of the original radiators, and they are still in good physical condition. Based on data from various railroads pertaining to the four-in. radiators, it is very difficult to establish a certain age to scrap radiators. We should also remember those radiators were used in a much more secure environment, as well as operating under lower pressures. There were at least five design changes and all performed well. Four-in. radiators usually fail at the header and have very few tube failures. Header thickness on the four-in. radiators are .090 and tube thickness .010. Overall scrap rate of the four-in. radiators is approximately 30 percent.

In 1955, starting with the GP-9, EMD switched to the six-in. single length radiator. A survey conducted ten years later showed a failure rate of approximately 10 percent. Most failures were tube to header failures. Scrap rate is approximately 13 percent. Headers on the six-in. single length radiators were .090 and tube thickness .010. Horsepower demands, increased labor costs and locomotive down time necessitated a more pressurized system as well as a more expedient way to replace radiators.

Along came the six-in. double length radiator. This eliminated one joint, which in turn eliminated another possible leak. This core was first used by some railroads on the SD-35 built in 1965. The early radiators were a stretched version of the six-in. single length core; headers were .090 and the tube thickness was .010. Failure rate of these cores was approximately 10 percent in the first nine months. Both tube and header leaks were found. This core design was improved around 1968 by changing the header thickness to .125 and the tube thickness to .012. The header thickness was further increased to .156 around 1970. The performance of those radiators was greatly improved by the design changes. Leaks are few and small, mostly tube to header leaks. Overall scrap rate on this core now is approximately 4 percent.

The eight-in. radiator is the worst performer of all. Several attempts were made to try to improve this radiator's performance. One of the first and most promising at the time was to use silicone rubber in place of the solder in the headers. Bench tests showed very good results. A number of units on a member railroad were equipped with this type of radiator, but after a few months in service, the silicone started to separate from the headers, and the idea was dropped. A significant improvement was to increase header thickness from .125 to .156. Since going to the .156 header, the estimated life of the radiator seems to have doubled. Average life of these radiators range from ten months on one road to three years on another.

The new mechanical bonded radiator sold by EMD shows promise of reducing the problem. The tubes are 50 percent thicker and do not have a lock seam to deteriorate. The mechanical bond is far superior to the solder joint and is not affected by temperatures. Most of us thought these radiators were new arrivals on the scene. Later we found that one road had purchased 184 cores in 1969. From time of purchase in 1969 until October 1976, two cores had failed because of freeze damage. They were repaired at a cost of $201 per radiator. The cost of these radiators is about $2,375 each.

There is another brand Mesabi Core, manufactured by L&M Radiator, Inc. in use on locomotives. These radiators are made up of individual tubes mounted in rubber grommets and placed in header plates making up a core. The tubes can be renewed individually. A member railroad gives a positive report on these radiators.

Touchstone is building a radiator of high-quality material with heavy-duty headers, core construction of heavy-duty tubes, heavy-duty fin material, high-grade solders and heavy-duty side rails to assure the support necessary for the long life demand. Several railroads represented on this committee are making application for evaluation.

Durox has developed a radiator that they indicate exceeds the original engine specification. Their eight-in. core includes eight stabilizing bars for the purpose of further rigidity. Several railroads indicate they are making application and evaluation of it as well as the four and six-in. covers to various types of power.

Failures in Radiators

Two types of radiator failures occur — at the solder joint that bonds the tube to the header, and tube leaks.

Tube to Header Failures

A majority of failures are tube to header. This occurs mostly at the outside rows of the radiator and usually on the air-in side of the radiator. That is where cold air meets the hot radiator. Most of the strength of the tube to header joint is at the space between the hole and the header plate and the tubes. Very little is contributed by the quarter inch or more of the puddle solder. Tests show that the radiators without puddle solder last almost as long as those with it.

When EMD switched to a silver bearing solder to sweat the tubes to the plate, a significant improvement resulted. By increasing the thickness of the radiator header, the area of the bond, sheer area, is increased, thus reducing stress. That is the reason for the longer life of the heavier header radiators. After failure takes place, the space between the tube and the header fills with scale. Dirt and oxide is found in the water. It is most important to remove all such deposits for the new solder to penetrate and get a good solder joint.

If that is not achieved, the repaired radiator will not last long.

In some extreme cases, penetration cannot be achieved unless the headers are pulled in order to clean the exposed tubes. A radiator that is improperly repaired will be almost impossible to repair the next time it fails. This accounts for the shorter life and higher scrap rates experienced by some roads.

Tube leaks are usually a result of poor design or manufacturing quality. Good quality radiators experience few tube leaks, while others have to be scrapped after a few months in service. Tubes must be supported by the fins; otherwise, the tubes will breathe due to the fluctuation in water temperature and pressure until a fatigue failure takes place. In addition, poor tube-to-fin contact will affect the transfer of heat. Most tube failures take place at the lock seam. The lock seam is filled with solder.

Any voids or defects will cause failures. Solder deteriorates with time. After some time in service, the solder in the lock seam will change it characteristics. If an excessive amount of heat is applied to the header during the repair process, tube leaks will develop close to the header.

Corrosion is another cause of tube leaks. Different types of corrosion can take place. One type is caused by flux or acid trapped in the radiator at the time it is repaired. That is why a repaired radiator should be submerged in an alkaline solution and then rinsed off properly. Other types of corrosion also take place. It is most important to have proper corrosion inhibitors in cooling water.

Failure Patterns

Most tube to header leaks take place in the outside row of tubes. That is where stress of water pressure and temperature would be greatest. Most tube to header failures take place at the air side of the core. That is where the temperature differentials are; therefore, the thermo stresses are largest. Most tube to header leaks take place where two cores are bolted together. Few leaks, in comparison, take place in the water-in and water-out ends of the radiator. Radiator failures have become more of a problem as the width of the header increased from four-in. to six-in. and then to eight-in. At the same time, water pressures, horsepower and operating temperatures increased. Some radiators have failed at a rate several times that of another name brand radiator.

Factors involved in radiator failure are as follows: thermo strains within a radiator, water pressure, thermo strains from fan and shutter sequence, restraints on radiator bank, engine-to-radiator connections, non-flat radiator header services, lack of alignment between cores, poor application of banks in locomotives, longitudal accelerations or strain, vibration, weakening of solder as temperature increases or decreases. A combination of those factors could be responsible for the failures. The most important in our opinion are thermo strains, water pressure, fan and shutter sequence, vibration, deflection of banks. Solutions to those failures are:

(1) Strengthening of radiators by using thicker headers, reinforcing outside rows or use of a mechanical bond.

(2) Isolating radiators from locomotive vibration with vibration pads.

(3) Modifying fan sequence to minimize cycling.

(4) Isolate radiators from each other with flexible couplers between radiator headers.

(5) Proper bracing of locomotive hatch to decrease vibration on radiators.

(6) Proper maintenance of radiators at the time of periodic maintenance of the locomotive.

(7) Proper inhibitors in cooling system.

Some railroads' running maintenance procedures are: cooling systems are pressure-tested using twenty lb. pressure at 30-day intervals. Radiators are washed and blown out with compressed air a minimum of once a year depending upon the environment where the locomotive is working. Cooling system pressure caps are tested annually and replaced at two-year intervals. In the event of a core failure, the entire affected bank is replaced with new or reconditioned cores. Some railroads date the cores in order to keep a cost record of the proper performance of the radiators. Maintenance points are required never to use more than 20 lb. pressure on radiators when pressure testing cooling systems. Proper jigs and fixtures must be used when lifting radiator cores and banks.

Some member roads have set up the following specifications:

All G.E. locomotives must have vent pipes applied in place of hoses, and piping properly wrapped. Vent lines must be installed so as to prevent water traps. Personnel must not stand on radiator banks when working in the radiator bank area. Plywood or some other means of protection should be utilized to protect tubes and fins from damage. When installing radiators in locomotives, radiator banks must be checked with straight edge and shimmed accordingly to assure proper weight distribution. Several railroads have discontinued the purchase of solder-type radiators, both new and secondhand, on all G.E. locomotives. Repair or reclamation of solder-type radiators at main shops is discontinued. Failed solder-type radiator cores are scrapped. Scrapped cores will be replaced exclusively with G.E. silicone-type radiators. All radiators removed at a scheduled Class I overhaul for cleaning and testing. Silicone radiators reaching second scheduled Class I overhaul should be scrapped if sixteen years old or older.

Replacement installation specify flat round radiator cores to SD-45 units until 100 percent of the units are equipped. Flat round radiator tubes should be in complete sets. Radiators removed will be cleaned and tested for leaks, and good cores repaired or unit exchanged. Radiator cores in excess of 18 years old will be scrapped. Radiators ten years old that require extensive repair will be scrapped. Only radiators that are newer than 1968 will be considered for complete re-solder one time only. The second time a radiator's cores require a complete re-solder at either header, it will be scrapped. Radiators will be marked to indicate repair date and to indicate date of complete re-solder. Header screens are being removed from all EMD radiators and locomotives operated without header screens on some roads.

The committee recommends the following manufacturer maintenance procedures:

1. Renew entire bank of radiators instead of a single core.
2. Pre-assemble radiators in approximate angle that radiators will rest in locomotive.
3. Clean radiators out frequently, determined by operating conditions.
4. Apply padding under banks to reduce vibration.
5. Apply flexible couplings between headers and wye pipe connections.
6. Secure and brace hatch to reduce vibration.
7. Convert to the flat round mechanical bonded radiator on SD-45 locomotives.
8. Proper inhibitor in cooling system.

Times have changed since railroads depended on a select few radiator manufacturers. Other companies are determined to capture some of the railroad business. This puts the railroads in a better position to bargain for and demand a better quality radiator.

V

DYE AND COOLING SYSTEMS

Water in its natural state has undesirable results on cooling systems. It causes corrosion, erosion, formation of sludge and scale. This can be controlled by the use of inhibitors.

Inhibitors used in proper concentration mark the beginning of good water system maintenance to prevent operating problems.

An example of water system maintenance is reflected in the following examples of one member railroad:

1. Teardown oil cooler to determine:
   a. Shell to header bond.
   b. Tube to header joint.
   c. Tube corrosion particularly in and around the water inlet.

   The teardown inspection showed that the oil cooler was in good overall condition, that is, free from deposits and corrosion.

   Micro-examination of the shell to header bond showed that there were no cracks or corrosion of the brazed joints.

Micro - examination of the tube to header bond showed that there were no cracks, erosion, or corrosion of the brazed joints.

Micro - examination of the inlet side of the tubes showed that there was no corrosion or erosion.

Visual examination of representative tubes showed that the inside diameter (water side) was coated with a thin, grey deposit. Under the deposit, the tubes were coated with a tight and adhering black varnish. There was no evidence on the tubes to indicate erosion, impingement or deposit types of corrosion.

This teardown was initiated to determine the cause of previous premature failures. The failures were caused by deposits and erosion of the tube. The failures occurred after a relative short service life. The laboratory suggests that this type of failure could be prevented by cooling system maintenance, that is, using a suitable water and a sufficient corrosion inhibitor to retard deposit formation and corrosion.

2. The overall result of the recent investigation showed that a good cooling system maintenance is being praticed, the tubes are clean and free of heavy deposits.

The second example is in the teardown inspection of eight locomotives, 16 years old with approximately 2,100,000 miles per unit. Inspection showed the inside of the water tank and water system piping to be nearly free of surface and flange crevice corrosion and rust or hard water flakes plugging the lube oil cooler.

These investigations indicate a necessity for maintaining proper cooling system inhibitors. All roads reported that a scheduled check of inhibitor concentration is made.

An aid to making positive identification of water leaks is florescent dye incorporated in the inhibitor at the time of manufacture. A concentrate can be made from powder florescent dye mixed 5½ lb. to 4 gallons of water. Put into ½-ounce bottles, one bottle can be added to each cooling system at each maintenance. Inhibitors containing mixtures of florescent dye will, when leaks occur, glow under a black light. The glow will appear as a green line consistent with area from which leakage occurs or if cooling system is charged with enough dye a leaking area will appear without the use of a black light.

Heads removed for water leaks, from engines containing the dye, leave a very clearly defined mark or greenish color at the point of the leak.

With maintenance schedules now used, this committee considers it a must to incorporate all the available tools to correct engine problems while units are shopped, thereby eliminating repeaters.

VI
AIR COMPRESSORS

The commitee has been advised by Triangle Engine Rebuilders that it now has available a new concept in lubrication, oil filtration and oil consumption control for Gardner Denver air compressors.

This concept consists of improvements and modifications engineered to provide maximum use of existing components at a minimal cost, and requiring a minimal amount of labor to apply.

Triangle has briefly described the modifications as follows:

1. A newly designed lubricating oil-pump plunger and crosspin that provides 13 percent more oil volume and eliminates high-speed cavitation.
2. A newly designed oil-pump filtration system that filters all oil flowing to the crankshaft.
3. A crankshaft modification to deliver this oil to crank pin journal at peak bearing loads.
4. Modification to the presently used pistons to eliminate the oil reservoir effect inside the piston and oil splash against the oil drain holes.
5. A set of new piston rings designed for quick ring seating with excellent oil control without subjecting the cylinders to excessive wear.

Triangle has dubbed this compressor as featuring "Friction-Fighter" full flow filter and oil control lubrication. This committee has been advised that the material for upgrading your own air compressor in your shop is available through them as well as the instructions to handle the various modifications necessary. This modification affords the railroad the ability to filter the lubricating oil as outlined above on its own rebuilt air compressors.

One railroad has made application of several WBG six-cylinder air compressors that are equipped with the low base or small capacity oil storage and have experienced some difficulty. Triangle has reviewed that difficulty and has apparently improved the design to perform satisfactory in this particular situation. At this juncture, however, the evaluation is not completed, but we understand that other railroads are experiencing very good life and reduced oil consumption with this operation.

Using the teardown inspection of the above failed air compressors, it was noticed that the cylinder walls, valves, and the top of pistons were very dry, indicating that the problem with oil carry-over in the air equipment had been virtually eliminated. The final analysis of the difficulty (referred to above) indicated an error in the check valve that has since been modified, and possibly will perform satisfactory in the future.

One railroad has initiated a test for oil consumption whereby a

tracer element, strontium, has been mixed with the air compressor's lube oil. As the test oil is supplemented with fresh oil, the strontium level will go down. Therefore, a correlation of oil consumption can be made.

We understand the filter kit using reconditioned parts would consist of a reconditioned modified oil pump, new modified design plunger, reconditioned strap assembly, new filter-type oil pressure regulator assembly, new spin-on-type oil filter, and a set of high-temperature flexible oil lines, fittings, gaskets, drill templates and the assembly instructions. Several railroads indicate that they have made application of this device in their shop for evaluation.

EMD also offers a conversion kit for WBO air compressor gear-type oil pump. This is described in detail in its Parts Pointer No. 5L-78 May 22, 1978, on page 4. This Parts Pointer advises that two gear-type oil pump conversion kits, Parts No. 9331736 and 933-9049 are available for converting a piston oil pump compressor to a gear-type oil pump compressor.

Compressor service life and reliability will be significantly increased as a result of the following benefits obtained through the gear-type oil pump conversion, which includes a full-flow oil filtration system:

1. Increased oil pumping capacity;
2. Pumping ability that is relatively unaffected by increase in oil viscosity;
3. Reduced component wear;
4. Long bearing life.

The 9331736 kit includes necessary hardware and the following parts to complete gear oil pump conversion.

1. Crankshaft,
2. Gear oil pump,
3. Bearing cover with oil introducing rings,
4. Filter assembly,
5. Two tube assemblies.

The 9339449 kit is similar to the 9331736 kit, but the price is 43 percent less as it does not include a crankshaft. This kit includes a drive gear and an application drawing for modifying existing crankshaft.

Maintenance instruction 1144 covers the basic teardown and rebuilding of the compressor. The gear-type oil pump conversion procedure is detailed in Maintenance Instruction 9621 and is further illustrated by application drawings provided with each kit.

In 1974 the General Electric Company introduced a new model Gardner Denver compressor that included the following features:

1. Constant displacement gear pump, resulting in less critical high viscosity and low temperature operation.
2. Lube oil filter system (clean oil reduces excessive wear and failures due to abrasive materials in crankcase).
3. Discharge valve, 2 disc 9 spring (improved performance, interchangeable with EMD).

4. Oil by-pass assembly (Reduced pump pulsations, constant oil flow and more stable oil pressure readings).
5. New style dip-stick all compressors (eliminates "lack of oil" failures due to hung up float gauges).

The General Electric Company has offered kits since 1975 for applying a filter arrangement to the suction-type pump (Catalog No. 2X3360), and also for applying the filter and gear pump (Catalog No. 2X3459 to the older style suction pump equipped units.

Inspection of numerous compressors in the field reveals that at overhaul some railroads are not using recommended renewal parts. Problems can develop, as follows:

Head Gasket —
Heavy gasket loose head bolts, water leak, blow-by;

Crankshaft Seals —
Incorrect seal can result in seal damage, oil leakage;

Taper Face Rings —
Flat face replacements cause excessive oil by-pass downstream and excessive wear;

Lube Oil Pump (Suction)
Oil Inlet Valve —
Do not interchange with EMD —EMD ball cavitates above 900 RPM—especially poor in low temperature operation;

Connecting Rods —
Odd brand inserts too wide — EMD is ⅛" > than GE — interferes with shaft radii;

2 Disc/9 Spring
Discharge Valve —
Can use GE on EMD; EMD 6 spring not recommended above 950 RPM;

Air Inlet Filters —
Non-recommended filter inserts a suspected source of abrasives resulting in excessive wear.

General Electric Bulletin No. GEK-35900 is published in the maintenance manual for air compressor maintenance.

The above reviews three different approaches to improved air compressor life to correct a difficulty needing improvement.

All air compressor manufacturers and remanufacturers should work toward the ability to add oil with the engine running.

Viscous Harmonic Dampers and Hydraulic Gear Dampers

After several years of in-plant testing followed by four years of field testing, EMD has released the gear damper for production to replace viscous dampers Part No. 8452042 (medium) and Part No. 8404560 (large). Those dampers are used on Model 645 turbo charged engines. The gear damper is being phased into production with full production slated for early 1979 and parts supply slated for mid-1979.

EMD has not accumulated enough test time on the gear damper to accurately determine its service life, but it is estimated to be equivalent to the nine-year life, which is specified for the viscous damper. Advantages of the gear damper include the following:

- reduced inventory requirements,
- less fragile than viscous damper,
- ability to disassemble, inspect and rebuild.

EMD has also released an item titled "Viscous Damper Qualification."

"Viscous Damper Qualification"

The sealed viscous damper, which is used to limit crankshaft torsional vibration on EMD engines, is subject to long-term internal wear and heat-enduced aging silicone-dampening fluids. These conditions can reduce the performance of the damper, but cannot be detected by visual and dimensional inspection procedures presented in the engine manual. The damper's performance level can be evaluated by measuring crankshaft torsional vibration. In the past, this has not been considered feasible for maintenance purposes because it has required elaborate laboratory instrumentation, highly skilled personnel, and several hours setup and test time per unit.

The situation has now been changed by the introduction of Scientific-Atlanta Model 2524 Torsional Order Analyzer. This is a portable, battery-powered analyzer with interical X-Y plotter. It is suitable for measuring and recording torsional vibration in EMD engines and other rotating machinery. It is relatively simple to operate compared with previously available instruments.

The Model 2524 Analyzer has two modes of operation. In the Order Plot mode, it tracks and plots torsional vibration displacement of a selected harmonic order against engine RPM as the engine is swept through its speed range. In the Histogram Plot mode, it performs a harmonic analysis of the composite vibration signal at a fixed engine speed and plots the amplitude of the vibration at each harmonic order from ½ through 9½, in ½ order increments. Scale setting and selected order or speed are automatically recorded on a 4 x 6-in. plotter card.

The combination vibration and speed signal is generated by the Scientific-Atlanta Model 9948-MJ Magnetic Sensor applied at the flywheel ring gear connected to the instrument through a coaxial cable assembly, Part No. 9839-NJ. The sensor must be mounted in a bracket provided by the railroad and bolted or clamped to the starter plate. With properly trained personnel, the setup and test time can be performed in less than ½-hour.

Since the vibration of each individual engine is slightly different, analysis of the torsiogram to determine whether or not the damper is suitable for continued service, requires a statistical comparison with the torsiogram from other engines of the same type. Through field tests of its instrument, Scientific-Atlanta has accumulated a large file of torsiograms from EMD engines, cross-referenced with damper tear-down inspection. They have demonstrated the ability to accurately predict the condition of a damper in a 20-cylinder engine from its torsiogram. Tests on the 12 and 16-cylinder engines are underway.

We have just received an update of damper qualifications test on 16-645E3 diesel locomotive engines dated December 6, 1978.

Several railroads have set up a routine practice of testing EMD viscous vibration and gear dampers and the following is the procedure that those railroads use.

TEST PROCEDURE

EMD Viscous Vibration Dampers

I. Testing of Dampers While on Locomotives

A — The primary tool for the testing of a viscous damper on an EMD unit is the Scientific-Atlanta Model 2524 Torsional Order Analyzer. This tool was developed in order to qualify a damper while in service, thus preventing some very costly crankshaft failures. A damper that is operated in a failed state can lead to crankshaft fatigue. The mechanism of fatigue is one of torsional, bending, or combined torsional-bending stresses.

B — Locomotives with viscous dampers should be tested as follows:

1. All units out of classified repair shall be tested within 30 days of being released from classified. This will establish a signature base upon which subsequent readings can be compared.
2. All units with viscous dampers shall be tested at time of six-month inspections. These readings shall be compared with established parameters in order to verify the damper's current condition.
3. All EMD units with viscous dampers shall be tested within 30 days of being shopped for classified repairs. The results of this preclassified test shall be forwarded to the backshop and used to determine further disposition of the damper.

Note: In the event a preclassified test cannot be done (damaged engine components, extensive wreck repairs, etc.), the last three-six months tests shall be used in order to declare the damper suitable for service.

C — Parameters

Four parameters have been developed in order to verify the current condition of the viscous damper. Two sets of parameters shall be used as the response characteristics of the 20-645E3 engine are somewhat different from the 16-645E3 engine. A brief description of the parameters is as follows:

1. **Peak Amplitude**
   The peak amplitude is by far the most important of the four. This parameter is the key indicator to dictate when it is

absolutely necessary to pull the damper in order to prevent a crankshaft failure.

2. Peak Frequency
   The peak frequency indicates whether the damper is tending toward a locked or free state. When the peak frequency begins to climb, this indicates mass is being taken away from the system. This condition would indicate that the viscosity of the fluid is going down or that a large shear gap has developed. When the peak frequency begins to go down, this condition indicates mass is being added to the system. This would indicate that the viscosity of the fluid is going up or perhaps the rotor inside the damper is beginning to bind. A high or low peak frequency alone is not sufficient evidence to condemn a damper.

3. Damping Factor
   The damping factor has proven to be useful in determining whether changes are taking place within the damper over a period of time. A high damping factor would indicate that the silicon fluid had jelled or solidified. This may also be a clue as to engine lube oil having migrated into the viscous damper. A low damping factor indicates the damper is either free or locked, depending on other parameter readings. Again, a high or low damping factor reading is insufficient on its own to condemn a damper.

4. Z Factor
   The Z factor is another parameter developed to simplify damper qualifications. Again this parameter alone is not sufficient evidence to condemn a damper.

D — Condemning Limits

The following limits have been established for use with 20 cylinder 645E3 engines. These threshholds are taken from the 5th order response.

Parameter	Upper Limit	Lower Limit
Peak Amplitude (mDSA)	12.0	7.0
Peak Frequency (RPM)	564	516
(Hz)	47	43
Damping Factor	.15	.08
Z Factor	5.0	.00

Note: It should be understood by all concerned that the above parameters do not apply to EMD's fully balanced crankshaft. Currently there are six 20 cylinder units of this type.

The following limits have been established for use with 16 cylinder 645E3 engines. These threshholds are taken from the 8th order response.

Parameter	Upper Limit	Lower Limit
Peak Amplitude (mDSA)	6.4	4.6
Peak Frequency (RPM)	405	372
(Hz)	54	49.6
Damping Factor	.10	.07
Z Factor	(Has not been established)	

II. Handling and Inspection Rules.

A — Whenever a damper is removed from a crankshaft, the following inspection shall be made:

1. The nominal internal clearance between the housing and the rotor is 0.015-in. Therefore, obvious dents in the housing is sufficient reason to send the damper in for rebuild.
2. When a straightedge is placed across the two rolled edges, the distance between the straightedge and front cover should be uniform around the damper. Maximum allowable variation is .020".
3. Evidence of silicon damping fluid at either rolled closure is sufficient reason to send the damper in for rebuild. This fluid is an extremely viscous colorless fluid under normal conditions. If engine lube oil has migrated through a bad seal in the damper, this fluid will take on a very dark, gummy appearance.

If a damper has passed the above inspection and if the preclassified tests declare the damper in good condition, then the damper may be reapplied for further service without further testing.

Note: In the event the preclassified test could not be done and the condition of the damper cannot be verified by previous tests, the damper should be sent back to the original manufacturer for verification.

If a damper has not passed the above inspection or preclassified testing indicates the damper to be failed, the damper should be sent in for rebuild.

Note: At the present time dampers can only be rebuilt one time; therefore, failed dampers that have already been rebuilt one time should be scrapped.

B — The following rules should be observed when handling a viscous damper:

1. When the damper is installed on the crankshaft, the crankshaft assembly should be supported at the intermediate crankshaft bearing locations. Do not support the weight on the damper or crankshaft gear.
2. Do not stack viscous dampers when removed from the shipping container. Dampers should be shipped in individual boxes made for that purpose.
3. Do not pry against the housing of the damper. Lifting, prying or stamping should be within a diameter of 14 inches on the mounting flange.
4. When viscous dampers are removed from crankshafts—where the damper is attached with four bolts and four dowels—the dowels should be pulled before the bolts are removed.

Hard Bore Liners

EMD has released a laser-hardened cylinder liner (port relief area only). It is the result of more than three years of field tests.

This liner (No. 9318831) has been basic on 645 turbo-charged engines since January 1978. It is recommended for use in 645 turbo charged engines in high horsepower, heavy-load service to assure maximum power assembly life.

Normally aspirated 645 engines can continue to use the standard cast-iron cylinder liner No. 841-5993.

Laser-beam hardened liners and standard cast-iron liners can be completely interchanged and can be intermixed in an engine. Also, all piston ring sets designed for use in standard cast-iron liners can be utilized in laser-hardened liners.

EMD has introduced a new technology in regular production to achieve greater wear-resistance of cylinder bore walls. This daily operation is believed to be the world's largest industrial application of high-power laser technology.

In the process, a ¾-in. wide beam is focused on the liner walls from within the cylinder by means of mirrors. As the cylinder is rotated, the laser circles the wall from the top to bottom in overlays of light. The result is uniform exposure and hardening. The walls are now radiated by a five-kilowatt, carbon dioxide laser beam. The result is a greatly hardened, more wear-resistant cylinder liner, according to EMD.

Past experience indicates that scuffing occurs when piston rings within the liners penetrate the thin film of oil to rub against the cylinder wall. Tests show that the new hard-bore liners may be expected to further minimize the amount of man-power and money spent by railroads on routine engine maintenance.

The liner is hardened to a depth of approximately .010 to .025-in. As of now only the port relief area is hardened. Tests show that this does greatly relieve scuffing of pistons and some port-milling.

This committee has been advised that several other methods have been tried, such as the use of "Melonite." Melonizing is generally performed after finish machining and heat treating. Core properties are unaffected, providing prior heat-treating temperature exceeds the melonizing temperature (usually 1075° F.). Treating time averages 30-90 minutes. The non-toxic salts employed in this process are oxidizing as opposed to reducing and the active cyanate agent is quickly regenerated by small reactive chemical addition. The process is said to be essentially non-polluting and also produces highly predictable, repeatable results.

The melonite bath is composed of mixed potassium-sodium-based cyanate and carbonate salts operating at 1075° F. The bath is continuously aerated to replenish oxygen depletion caused by cyanate reaction with ferrite. Restoration of other bath constituents is accomplished by small, erratic additions of a regenerative organic agent. Bailout or replacement of

the salt for chemical reasons is not required.

We understand that a problem was experienced with this process on EMD's three-piece welded liner. The treatment distorted and/or damaged the welds. To our knowledge, this treatment has never been applied to an EMD liner successfully, and tested in a locomotive. Another process has been experimented with under the trade name of "Tridaloy Intermetallic Materials." Again to our knowledge, this process has never been applied to a locomotive cylinder liner.

General Electric has a method of hardening its liners, which is referred as "Tufftrided." We are advised that the Tufftrided process has proved very feasible. It features a number of manufacturing advantages. Processing costs are lowered and secondary honing and blasting operations can be eliminated. Tests show reduced piston-ring wear with the new Tufftrided liner. Scoring and scuffing of both liner and rings were also found to be reduced as was cylinder-liner wear, particularly in upper portion, where temperature and lubrication conditions are most severe.

Cylinder liners can be honed prior to Tufftriding. The delicate cross-hatch honing pattern achieved is not disturbed by Tufftriding, although it becomes slightly less visible to the naked eye.

The Tufftrided process is a temperature (1060° F.) salt bath nitriding process used to improve wear and fatigue properties of all ferrous metals. Wear properties of cast iron are reported to have been improved as much as 300 percent to 400 percent.

After extensive field testing concluded about four years ago, G.E.'s current production is of Tufftrided cylinder liners. We understand that G.E. also is making tests and application of the previously mentioned "Melonite" Process. The difference in the liners is in the hardening process only. Once the liners are completely manufactured, there is no difference in assembly, piston ring combination, wear, oil consumption, or salvage methods compared to G.E.'s present Tufftrided liners.

We understand that the Melonite process has been tested in the G.E. engine laboratory for approximately two years with excellent results. G.E. has Melonite processed liners operating on several railroads.

G.E. also states that its turbocharged engine is not subject to extra normal wear because it runs hotter. The turbocharged engine has a better air ratio to fuel than a naturally aspirated engine. With the proper scavage air, a 4-cycle engine does not necessarily run hotter.

Although such processes seem very good for the original manufacturer, at this point, we do not know all the results of reconditioning or reusing of liners that have

been manufactured with these processes. We understand that the laser-hardened surface can be honed without damage. However, it may hone through and lose its identity. Since the EMD liner is only hardened in the port area, it will not improve the wear characteristics at the upper surfaces of the liner where wear is the greatest. It does appear, however, that it will reduce scoring in the port area.

We understand that G.E. is experimenting with rehoning and retufftriding liners that have been in service. Additional runs were made to evaluate the oversized limitations. This test is not conclusive yet.

Another process used for years to combat wear in diesel engine liners is chrome-plating of cylinder liners. That has proven cost-effective in prolonging the operating life of the diesel engine, especially the cylinder liner. Several companies have developed their own proprietary methods of chrome-plating in which the porous surface can be applied to the chromium to permit pockets and/or channels for lube oil to lubricate the piston ring travel. Varying degrees of porosity are available to tailor the lube oil retention of the chromium surface to the operating characteristics of the diesel engine. The chrome-plating process offers two major approaches—restorative plating to salvage worn liners, and preventative plating to condition new liners prior to service. Both approaches offer the railroads a substantial cost saving in the purchase of replacement new liners.

The chrome-plating of diesel engine liners also offers another major benefit in operation of turbo-charged 2-cycle engines. Those engines are subject to abnormal wear because they require more air and fuel to run hotter and faster. The excellent wear characteristics of chrome-plating is ideally suited for use in turbocharged engines, particularly for liners.

Air-borne dirt can cause extreme scoring of a chrome liner which does not have the self-healing property of an iron surface liner. We must continue to evaluate the various processes. While chrome plating does offer the ability to restore to standard size, it may be more vulnerable to dirt in the oil, or other contacts may cause a chrome surface to become a self-generating failure.

There are a number of factors contributing to wear in diesel engine liners, but a definition of wear is useful in establishing the criteria for preventing, or at least retarding, its effect.

In "An Analysis of the Factors which Influence the Cylinder Wear in Diesel Engines," Carl Hoegh says: "Wear, in the particular meaning of the word, as generally used in engineering, is the unwanted destruction and wastage of material caused by mechanical agencies. Also, electro chemical and chemical agencies very often play an important part in the process."

Van Der Horst Corporation of America has described two general categories of wear, which are mechanical and chemical, as listed below:

1. Abrasion—two surfaces rubbed against each other under load.
2. Erosion—liquid or gas streams past a metal surface at high velocity, especially carrying solid particles.
3. Gas-Erosion — melting of a metal surface over which a gas streams past at high velocity, carrying away melted particles.
4. Friction—two metal surfaces rubbed against each other, with a rise in temperature, confined in the area of contact.
5. Frictional Oxidation—friction-caused plastic deformation of the surfaces in the presence of oxygen.
6. Corrosion—destruction of material through electro chemical or chemical reaction caused by adjacent substance.

This Committee recommends good air and oil filter maintenance to improve the environment the engine must have in order to reduce wear on components.

Progress Toward Elimination of Oil Leaks

This Committee was asked to consider a request submitted to the LMOA. This suggestion had to do with cleanliness. It was implied that it is high time that the manufacturers of diesel engines learn how to build an engine that doesn't leak oil all over the place.

At least one railroad and perhaps most manufacturers have made some progress on this. However, the manufacturers have not acknowledged any progress. One railroad has made test application of Loctite Gasket Eliminator 515 for evaluation on EMD engines.

The following are the flanges that were chosen to test the full capabilities of this gasketing product. (See page 328.)

A standard caulking gun was used to apply a bead of Product 515 to the center of the flange area, and all bolt holes were circled. Two tubes (600cc's) of Product 515 were used to assemble the entire engine at an approximate material cost of $30.00. This test was started late in 1978 and will be reviewed and later evaluations made .

After six months of service, this one engine looks good enough to justify further application.

Location	Comments
1. Top deck frame (both frames).	Applied to crankcase; left side. Had to be adjusted to fit.
2. Oil pan to crankcase.	Applied on both sides of rubber seal.
3. Accessory drive cover.	Applied on cover. Locquic Primer N was sprayed on crankcase to assist cure.
4. OST cover to crankcase.	Applied to OST cover. Primer N sprayed on crankcase. Surface of cover was heavily pitted. Left side of cover had a gap of approximately .030-in.
5. Scavenging oil pump.	Applied to accessory housing.
6. Lube oil pump.	Applied to accessory housing.
7. Water pump (two pumps).	Applied to accessory housing.
8. Govenor drive base.	Applied to accessory housing.
9. Blower end housing.	Applied to housing.
10. Blower end housing adapter.	Applied to adapter. Not all bolts were assembled since the balance of the engine was not ready to assemble.

Wednesday, September 19, 1979

8:30 A.M.

REPORT OF THE COMMITTEE ON SHOP EQUIPMENT

Pre-Convention Presentation: Union Pacific Shops Omaha, Nebraska

April 17, 1979 Omaha Hilton Omaha, Nebraska

T. E. WHITTEN, Chairman
Manager Production Control
Illinois Central Gulf Railroad
Paducah, KY 42001

VICE CHAIRMAN

T. A. Kessenger, Senior Engineer Facility Planning, Louisville & Nashville Railroad, 908 W. Broadway, Louisville, KY 40203

COMMITTEE MEMBERS

J. E. Abramson, Shop Superintendent, Duluth Missabe & Iron Range Railway, Proctor, MN 55810

K. O. Anderson, Manager Maintenance Engineering & Education, General Electric Co., Erie, PA 16501

P. F. Hoerath, Superintendent Plant Maintenance, Consolidated Rail Corp., Altoona, PA 16603

T. F. Kelly, Superintendent Locomotive Shops, Chicago, Rock Island & Pacific Railroad, Silvis, IL 61282

T. D. Lemons, Assistant Superintendent, Missouri Pacific Railroad, St. Louis, MO 63103

M. G. Marler, Mechanical Superintendent Shops, Union Pacific Railroad, Omaha, NE 68179

R. P. McFarland, Manager Industrial Engineering, Southern Pacific Transp. Co., San Francisco, CA 94105

E. N. Messer, General Foreman, Chessie System, Russell, KY 41169

G. A. Minnix, General Foreman, Norfolk & Western Railway, Roanoke, VA 24011

N. J. Nielson, Shop Superintendent, Chicago, Milwaukee, St. Paul & Pacific Railroad, Milwaukee, WI 53201

R. V. Propp, Shop Superintendent, Burlington Northern, Inc., Burlington, IA 52601

L. G. Salts, Engineering Assistant, Atchison, Topeka & Santa Fe Railway Co., Topeka, KS 66616

G. B. Sweeney, General Foreman, Southern Railway Co., Atlanta, GA 30315

J. J. Wheelihan, Supervisor Product Installation, Electro-Motive Division, LaGrange, IL 60525

1979 TOPIC:
"SHOP EQUIPMENT — IT 'AIN'T' JUST THE SAME OLD TOOLS"

PERSONAL HISTORY

THOMAS E. WHITTEN

Thomas Whitten came into this world in Memphis, Tennessee on November 17, 1948. He attended public schools in Memphis, Tennessee and Hernando, Mississippi, graduating from Hernando High School in 1966. He entered the University of Mississippi (Ole Miss) in 1967 and was graduated in 1971 with a Bachelor of Science Degree in Mechanical Engineering. Entering the University of Mississippi graduate school in 1971, Tom acquired a Master of Science Degree in Engineering Science in 1973.

In August of 1973, Tom started his railroad career with the Illinois Central Gulf Railroad as a Facility Analyst in Chicago. He was promoted in 1974 to Coordinator Research and Planning at ICG's Paducah Shop, Paducah, Kentucky. He has progressively been promoted to Supervisor of Manufacturing, Engineering and Planning Department, to Supervisor Mechanical and Industrial Engineering, to Assistant Manager Production Control to his present position as Manager Production Planning and Control.

Tom has been an active member of LMOA since 1973 and a committee member since 1974. He is an avid outdoorsman (hunting and fishing) and enjoys spectator sports (football and baseball (Ole Miss) and auto racing). He is an active member of the University of Mississippi Alumni Association.

Tom was married to Pamela A. Refkofsky of Bridgeport, Connecticut on June 30, 1972. At present, they have no children.

INTRODUCTION

In this day and time, it is not uncommon to discover in locomotive shops worldwide: tools, machines, and processes in use that date back many, many years. If the question is asked why there has been no improvement or update, the old cliches are often heard: "It has worked well for years—why change?" "It was here when I took the job" "We don't have the money." The reasons for change, as we all realize, are there—increased productivity, cost reduction, improvement of work conditions, improved quality and of course "we must keep rolling stock rolling."

The Shop Equipment Committee will present new tools, machines, and processes that will demonstrate to railroad management the continually changing and improving field of railroad equipment. Upon review of the data presented by this committee, you will come to the realization that "It Ain't Just The Same Old Tools."

As managers of locomotive maintenance, in an ever improving industry, you must be abreast of the developments occurring within your industry. This committee endeavors to keep you informed by presenting the following:

I. New Facets in Locomotive Journal Box Repairs

II. Update and Re-evaluation of Power Assembly Repair Lines
III. New Concepts in Tools
IV. Update on Wheel Truing
V. Concepts in Streamlining Ready Tracks for Locomotives
VI. Update on Locomotive Cleaning and Washing Equipment
VII. Micro-Processor — Application for Tooling (Machine)

I. NEW FACETS IN LOCOMOTIVE JOURNAL BOX REPAIRS

One railroad has installed new cleaning equipment, conveyors and improvements to clean and rebuild locomotive journal boxes. The railroad was experiencing daily production delays as a result of cleaning equipment failures and lack of capacity to process parts and reassemble journal boxes. Upgrading of the entire operation was necessary to increase operator productivity and improve product quality (Figure 1).

The railroad faced two alternatives:

1. Add manpower on second and third shift

   Advantages —
   a. Increased production

   Disadvantages —
   a. Increased cost of product
   b. No improvement in product quality

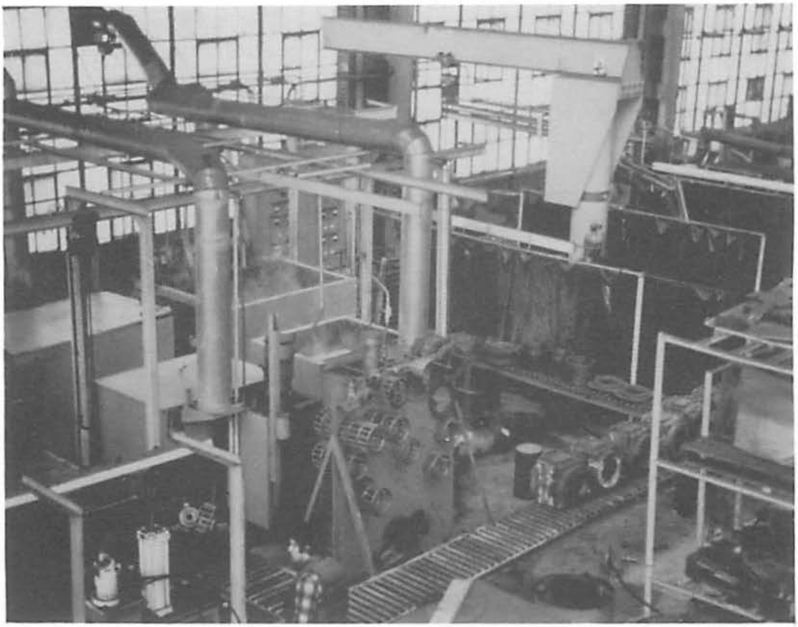


FIG. 1

2. Relocate journal box line and upgrade equipment
   Advantages—
   a. Increased production
   b. Reduced product cost
   c. Improved quality
   d. Expansion area provided for traction motor assembly
   e. Efficiency improvement
   f. Improved work flow
   g. Reduced material and labor waste

Upgrading action taken by the railroad was as follows:

1. Designed and installed a high pressure steam pre-cleaner to remove road dirt and excess grease (Figure 2).
2. Designed and built pump-agitated cleaning vats with effective rinse and ventilation systems to permit the use of faster acting cleaning agents (Figure 3).
3. Improved safety in the weld areas by adequately ventilating fumes and shielding the weld booths (Figure 4).
4. Upgrading work stations with new hydraulic bearing pressing equipment, parts bins and conveyors.
5. Rearranged journal box line to prevent mixture of clean and dirty parts.

In upgrading the cleaning and rinsing procedure, three cleaning vats and two rinse vats were designed and built.

#1 Washer for journal boxes and races

#2 Rinse unit for boxes and races

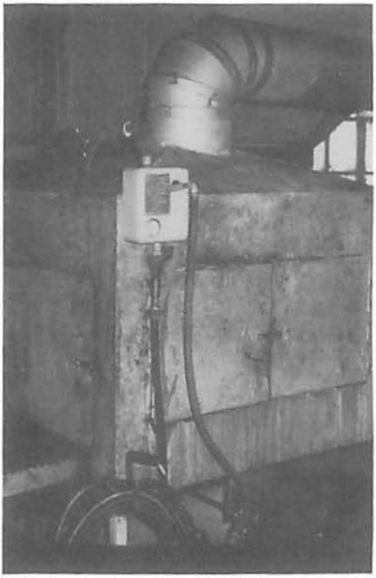


FIG. 2

FIG. 3

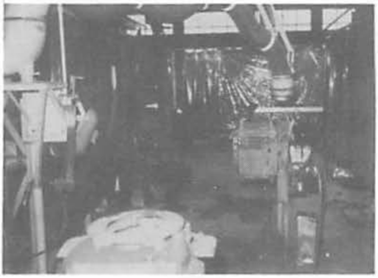


FIG. 4

#3 Washer for thrust bearings, cages and rings

#4 Rinse unit for thrust bearings cages and rings

#5 Roller bearing washer.

The process for working journal boxes through the line is as follows:

Skids with journal boxes to be reworked are brought by lift truck to the inbound storage area, six boxes per skid. The journal boxes are lifted by jib crane and lifting chains from the skids and placed on a roller conveyor for processing through Station #1 (steam prewash). The oil drain plug is opened allowing the oil to drain through the conveyor into a catch pan. The journal box is turned so the axle hole faces front, toward the washer. The journal box is pushed by hand into the washer cabinet, centering it between the steam jets. The doors are closed and latched and steam cleaning is activated. The journal box is steamed for 5 minutes. The front doors of the washer are opened and a steamerette steam wand is used to blast off stubborn dirt on the bolt heads and under the adjacent ring. The steam wand is deactivated and the journal box is removed by using a grab hook to Station #2 (Stripping).

The journal box is stripped and the race pressed out. At this point the box is broken into its various components; box, race, cages, roller bearings, thrust bearings, rings, etc. The line now divides into two separate lines with individual washers for (1) roller bearings (Station #4A), (2) thrust bearings, rings, and cages (Station 4B), and (3) boxes and races (Station 3).

The first line is for cleaning the boxes and races, and reworking the boxes. The boxes and races are moved to Station #3 (box and race washer). The boxes and races are placed in a basket with capacity for three boxes worth of components. The basket of components is moved by overhead monorail, lowered into the box and race washer, and washed for 30 to 45 minutes. The basket is then raised by the monorail, moved to the rinse vat, lowered into the rinse vat and rinsed for five minutes. The basket is then lifted by monorail and removed from the rinse vat. The races are removed from the basket and stored on a roller conveyor for movement to Station #6 (assembly area).

The boxes are moved by roller conveyor to Station #5 (box rework area). The boxes are handled from the conveyor by a jib crane and lifting chains. The boxes are loaded into welding fixtures and the worn wear plates are burned off with air arc and new wear plates are put on by arc welding. The reworked boxes are then loaded back on the roller conveyor for movement to Station #6 (assembly area).

The second line is for cleaning the roller bearings, cages, thrust bearings, and rings. The roller bearings are processed from Station #2 (stripping) to Station 4A

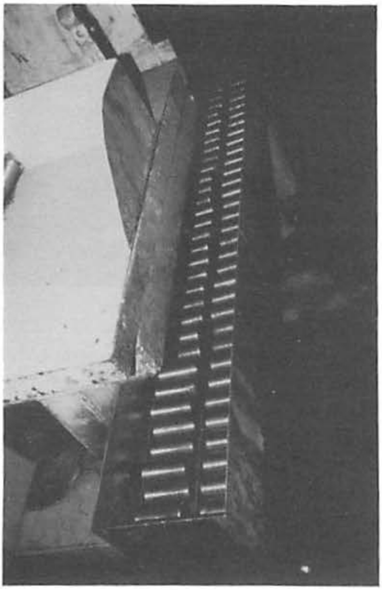


FIG. 5

(roller bearing washer) (Figure 5). The washer is a gravity flow washer tray which also serves as a conveyor to bring the rollers to Station #6 (assembly area).

The machinist stripping the journal box places the cage with the bearings onto a holding fixture and removes and stacks the bearings for insertion into the roller bearing washer.

The roller bearing washer is a trough, holding two side-by-side rows of roller bearings on tracks. The tracks are slanted so that the rollers rub face-to-face, thereby abrading dirt accumulations, while rolling in mineral spirits toward Station #6 (assembly area).

An assembler then removes the bearings one at a time, wipes them, visually inspects for defects, gauges for size with a dial indicator, and stacks reusable bearings aside for future use.

The cages, thrust bearings, and rings are processed to Station 4B (cage, thrust bearings, and ring washer) by jib crane and loaded into a basket with capacity for four boxes worth of components. The basket of components is moved by overhead monorail, lowered into the washer, and washed for one hour. The basket is then raised by monorail, moved to the rinse vat, lowered into the rinse vat and rinsed for five minutes. The monorail next lifts the basket and removes it from the rinse vat. The cages, thrust bearings, and rings are then processed along with the boxes and races to Station #6 (assembly area).

All components are now on roller conveyors in Station #6 (assembly). The various components are moved into the assembly area on a bearing transfer table and the journal boxes are assembled. Convenient gravity feed material bins for bolts, washers, etc. are located above the table. The completed journal boxes are loaded on skids in the outbound storage area for processing from the area.

II. UPDATE AND RE-EVALUATION OF POWER ASSEMBLY REPAIR LINES

Fast, high-quality methods of removing, repairing, and applying power assemblies are very essential for the efficient operation of locomotive repair facilities. Some methods presently used in this area of locomotive repair will be discussed.

One railroad sends EMD locomotives to its system assembly shop on a periodic basis for the changeout of sets of power assemblies. Prime movers remain in the locomotives during these changeouts. An overhead crane lifts the complete power packs from the prime mover and places them into racks. The racks, containing eight power packs each, are taken to the strip area on motorized dollies.

At other locations on the railroad, individual assembly components are removed from locomotives at failure and are shipped to the assembly shop strip area in special color-coded containers.

In the strip area, the power packs are disassembled into major components, ie; heads, liners, pistons, and rods. The major components are further disassembled and the small components are separated.

Using jib cranes, major components are hung on special fixtures on a continuous, chain-driven monorail conveyor (Figure 6). Baskets containing individual small parts are hung on hooks on the conveyor. The conveyor takes the parts through a four-stage chemical wash machine. The parts are sprayed with cleaner, dipped into a cleaning vat, rinsed and sprayed with a rust inhibitor. The conveyor then takes the parts to individual parts rework areas.

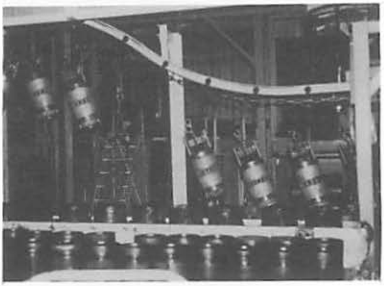


FIG. 6

Piston ring grooves are inspected and are oversized 1/64 inch or 1/32 inch on a vertical lathe if it is required. Piston interiors are blasted with steel shot to remove carbon in the undercrown area. It is very important that this area is free of carbon so that proper piston cooling can be achieved. The exteriors of the pistons are cleaned in an automatic glass bead blast machine. The pistons are then inspected for cracks in a Magnaflux machine. Piston surfaces are prepared for proper retention of lubricant in a Lube-rite machine. The Lube-rite machine consists of three vats, and an automatic arm and holding fixture. The arm picks up two pistons and lowers them into a hot water vat. They are left there until heated to the proper temperature. The pistons are then dipped into a phosphoric acid vat to make the piston surfaces porous. The pistons are then rinsed in the hot water vat and are finally dipped into an oil-water solution.

Liners are water tested at approximately 90 p.s.i. Liner bores are honed to a 35 to 45 micro-inch finish. The honing machine is

equipped with 0.030 inch and 0.060 inch gage rings. When bore-oversizing is necessary to salvage liners worn beyond limits, the bores are honed until the gage ring drops into the bore, automatically turning the machine off. The liners are then run back through the cleaning cycle. Chrome plating is also used to salvage some worn liners. Oversized liners are installed in matched sets in locomotives in the assembly shop. Only standard or chrome plated liners are sent to other locations on the railroad to prevent mismatching of parts.

Heads are cleaned in an automatic glass bead blast machine. A 200 p.s.i. water test is applied to each head. Heads are Magnifluxed. Valve guides are checked and replaced if necessary. Valve seats are ground. Heads are then recleaned in a special spray-wash machine.

Exhaust valves are cleaned in an automatic glass bead blast machine. They are tested for stretch and are ground to specifications. Valve seats are checked for cracks using an eddy current process (Figure 7).

Valve springs are tested for compression and free height on an automatic testing machine. Springs which meet the test criteria are reused.

Injectors are cleaned, checked for leaks, and pop-tested. Rebuild dates are checked. They are reused if they have been rebuilt during the past year. Bad-order injectors and injectors out of date are rebuilt.

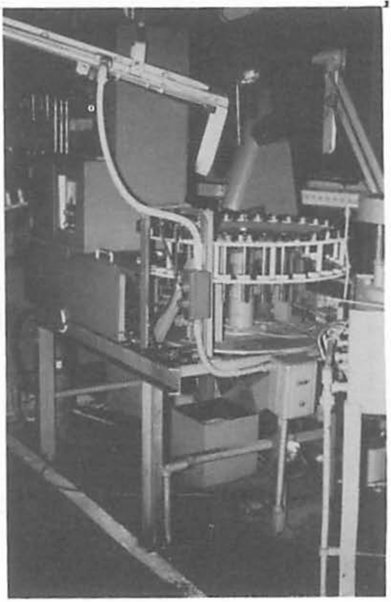
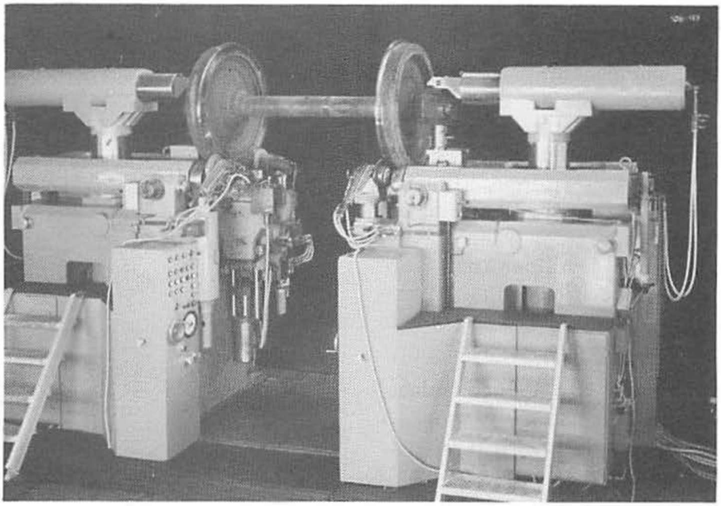


FIG. 7

Test cocks are disassembled, cleaned, rethreaded and reseated. The test cocks are then reassembled handtight and are set upside down on a table. They are then filled with mineral spirits. After thirty minutes, the cocks are checked to see if the fluid leaked down; seats on defective cocks are then reground.

Valve bridges are checked for broken springs and proper seating. Hydraulic lash adjusters are removed, reconditioned, individually tested, and reapplied to valve bridges.

Piston fork and blade rods are checked for proper length and are Magnafluxed. The fork rod basket



bolt threads are also cleaned. Piston pins, carriers and baskets are also Magnafluxed.

Small component parts are applied to the major components. Rods are attached to piston pins on a hydraulic torque machine preset to the specific torque. Finally, the power packs are reassembled, using new and reconditioned components. Head-to-liner nuts are torqued to specified values in one operation using an eight-spindle air-operated torque wrench.

Power packs are applied to locomotives in the assembly shop. A hydraulic torque wrench is used to torque crab nuts. Component parts are shipped to other locations when needed.

Engine assembly sets are changed out every 3 to 5 years, depending upon locomotive type, mileage, and service in which the locomotive is used. This frequency of changeouts has reduced power assembly failures and the resulting inefficient process of changing out assemblies in running repair operations.

At present, on this railroad, the power assembly failure rate for approximately 1300 locomotives is 800 per year, or 0.6 assembly per locomotive per year.

On one railroad, sets of GE power assemblies are changed out every 3½ years in a central shop. The assemblies are removed from engines mounted in locomotives and are overhauled using a system of ramps, jib cranes, a continuous monorail loop, gravity roller conveyors, and various machines and devices.

Permanent ramps installed at the level of locomotive running boards make the removal and application of power assemblies safe and efficient. Also, portable ramps are used where additional height is required (Figure 8).

FIG. 8

Covers are removed from the cylinders, and after gaskets are removed, the covers travel in baskets on a conveyor through cleaning and rinse vats, and on to the cylinder parts inspection and rework area. After inspection and repair, new gaskets are applied and the covers are placed in a storage area until they are needed back on the locomotive. Fuel injectors are removed and are shipped off for unit exchange. A lifter is applied to each cylinder. A two-ton jib crane, located between the two heavy repair tracks, pulls the cylinders off the pistons and hangs then on individual dollies on the continuous-loop monorail. The cylinders are moved to the disassembly area by one of

four electric-powered, push-button controlled pullers used on the monorail loop. A stainless steel protective sleeve is placed on each piston to protect it from being scarred when the engine is barred over. A pneumatic, portable, remote-controlled bar-over device is used to bar the engine over. The jib crane removes the piston assemblies and places them on individual aluminum plates on a split conveyor which takes them to the disassembly area.

A ramp within the monorail loop at the cylinder disassembly area and assembly area places a man at a convenient height to work on the cylinder assemblies. Empty parts baskets from the cylinder parts inspection and rework area roll on conveyors to the end of the ramp. A hydraulic lifter raises the sections of the conveyors containing the baskets to the level of the ramp. Each cylinder is spotted on the monorail next to the baskets. A special fixture anchors the cylinder to the ramp so that it will be held steady while parts are being removed. Parts are removed from the cylinders and are put into the baskets; aluminum parts go on one conveyor, and steel parts go on the other. Fuel pumps are placed into containers on a conveyor and roll to the shipping and receiving area. The stripped cylinders (liners and heads with valves still installed) are removed from the monorail using special shipping containers on a fork lift and are shipped off for unit exchange. The containers of fuel pumps (3 pumps per container) are removed from the ramp using a pallet on a fork lift and are shipped off for unit exchange. In this shipping and receiving area, stripped cylinders back from unit exchange are hung onto the monorail using a fork lift. They are then pulled to the assembly area. Also, in this same area, containers of fuel pumps back from unit exchange are lifted up to the ramp with a fork lift. They are placed on a conveyor and roll to the assembly area.

The baskets containing the cylinder parts continue on the conveyors through cleaning and rinse vats. Aluminum parts are cleaned in one vat and steel parts are cleaned in another. After cleaning, the baskets of parts roll on to the cylinder parts inspection and rework area. All parts are inspected and repaired or replaced as needed. Steel parts are checked for cracks in a Magna Glo machine. Sets of parts for cylinders are put into special containers and are lifted up to the monorail ramp on the hydraulic-operated roller conveyor section. On the ramp, the containers are placed on a conveyor and roll to the assembly area. Parts are installed on the cylinders while they hang on the monorail. The special anchor fixtures are used here to hold the cylinders steady while parts are being applied. Empty parts containers are returned to the cylinder parts inspection and rework area on a chute.

In the piston disassembly area, piston assemblies are removed from the conveyor and are placed on a hydraulic disassembly machine using a jib crane and a special lifting and turning device. Parts are put into baskets on conveyors that take them through the cleaning vats and on to the assembly area. All parts are inspected and repaired or replaced. Rods are checked for straightness. Piston crowns are further cleaned in an aluminum oxide blast cleaning machine. Steel parts are Magnagloed. Skirts are applied to the crowns and these assemblies are placed on a rotation machine for ring groove cleaning. Rods and pins are applied to the pistons on a hydraulic assembly machine. The piston assemblies are placed on aluminum plates on a split conveyor using a jib crane and the lifting and turning device. The piston assemblies roll to the piston installation area.

As each piston reaches the end of the conveyor, rings are applied and a hydraulic cylinder pushes the piston into the cylinder which is hanging directly above on the monorail. One man standing on a ramp at the piston installation location uses hand and foot controls to move the cylinders and pistons into position, to install the pistons into the cylinders, and to pull the cylinder-piston assemblies back to the locomotive in the heavy repair area. The two-ton jib crane installs the cylinder-piston assemblies into the locomotive. A pneumatic torque wrench is used to torque cylinder holddown bolts.

A complete set of cylinder-pistons is kept built up and stored in racks located conveniently to locomotives in all areas of the shop.

Another railroad breaks GE assemblies down into major components, ie., head, liner, and jacket. After all component parts are removed from the assembly, a liner and head removal fixture is applied. Using this fixture, which has stems that contact the head, the head and liner are pressed out of the jacket.

All parts are cleaned, inspected and repaired or replaced. Heads and liners are glass-bead blasted. Liners and jackets are hone-cleaned. Liners with bores worn beyond gage limits are rechromed. Head valve seats and valve seats are ground.

Lifting and turning devices are attached to jackets ready for reuse. Jackets are placed upside down on plates on a roller conveyor supply line. A jacket is rolled to the assembly press. A dummy head and a four-stem fixture are used to line up the head being applied with the relief cock. Gaskets are applied to the cylinder and the head. A head is set into the jacket and a liner is lifted into position over the head. This assembly is rolled under the press, and the cylinder and head are pressed into the jacket in one operation using 45 tons of force. A liner clamping ring is bolted on and torqued while the press maintains the 45 tons.

The cylinder assembly is turned upright and is lifted onto a hydraulic test fixture piston. Cylinder hold-down bolts are applied. Hydraulic pressure is applied through the relief cock hole.

Valves are placed into position, and the assembly is set onto a stand and is rolled under the valve spring press. Valve springs and spring seats, umbrellas, and rotators are applied. The springs are compressed and keepers are applied to the valve stems.

The assembly is rolled onto a tilt table. The table turns the assembly on its side, and it is pushed onto the water test conveyor. A 50 p.s.i. water test is applied to eight cylinders simultaneously.

Remaining parts are applied to the cylinder assemblies, and they are ready for use.

III. NEW CONCEPTS IN TOOLS

A — Balance Technology

Unbalance is simply the uneven distribution of weight when put into motion. It becomes uncontrolled power causing vibration in rotating equipment.

One ounce of unbalance one inch away from the center of the axis of a rotating object becomes a force of 45 lbs 10 ozs at 5,000 rpm.

Vibration caused by the unbalance of rotating equipment on locomotives results in wear and/or failure to bearings and equipment directly connected to the rotating part, and will also cause wear and malfunction to stationary mounted equipment on the locomotive due to the vibration transmitted throughout the frame and car body.

Most railroads that have been involved in traction motor and main generator repair have balance armatures with various types of balancing machines. With the modern balancing machines distributed by Bear and Giddings & Lewis, it is possible to balance most any rotating part on a locomotive.

The machines are simple to operate and automatically calibrated to indicate the amount of weight needed and the angle of unbalance.

There are optional features such as digital read-out, drilling, punching, or welding equipment mounted on the machine so balance can be effected without removing the piece from the balancing machine.

Static balancing is a weighting process for a part which is free to turn on an axis. The balance is accomplished by adding weight to the light sections or removing weight from the heavy sections so that when rotating the part can be brought to a stop with any point on the circumference in line with the axis and will remain in this position.

Dynamic balancing is accomplished by rotating the part at sufficient speed to indicate the centrifugal force caused by the unbalance so that the amount of unbalance can be measured and located.

The Bear Dynamic Balancing Machine will reveal both the static and dynamic unbalance condition while the machine is running and

will indicate with great accuracy the amount and angle of unbalance on the dials so accurate connections can be made without reversing the part in the machine. These conditions indicated on the meters remain displayed until the next cycle is started on the machine.

Giddings & Lewis Gilman/Gisholt offer five machines most adaptable to railroad use as follows:

1. A vertical, single plane rotating balancer with drill for correcting. Part range up to 24-inch diameter and 100 lbs.
2. A non-rotating single plane balancer for parts up to 250 lbs.
3. A two-plane horizontal machine for parts up to 5,000 lbs. The part is end driven with a drive coupling from the left side.
4. A two-plane horizontal machine for parts up to 5,000 lbs. Part is driven with a belt from below.
5. A larger two-plane machine for parts up to 20,000 lbs. This is an end drive.

B — Shock Pulse Meter (Figure 9)

Several methods are presently being used for monitoring bearing conditions. Perhaps the most common is vibration analysis, although changes in temperature and noise level are used in an attempt to predict bearing failure. All three of the above can be influenced by outside factors other than bearing conditions. Since vibration is most widely used it deserves comment.

A change of speed, mass or alignment of any part of the machine will cause some change in its vibration spectrum. Seeing that a change has taken place is quite obvious on reliable vibration equipment; predicting reasons for this change is less easy. In many cases, the detection of failures is performed between the range of 20Hz and 20kHz when using vibration spectrum analysis. It is quite possible that the bearing can reach an advanced stage of damage before the vibration peaks at the frequencies related to the speed of rotation increase above that of the background noise level. It is also true that the bearing may well be severely damaged before the change in the readout equipment is sufficiently large to be meaningful using temperature and noise measurement equipment.

Due to this lack of available equipment to predict accurately and simply the condition of antifriction bearings over their life cycle, an invention was developed in Sweden in 1966. It was quite properly named "The Shock Pulse Method."

The Shock Pulse Method (SPM) provides a completely new approach in both theory and application for the measurement of rolling type bearings. It has resulted in a new technique allowing a quantitative measurement of bearing operating condition. The SPM measures indirectly the velocity of a mechanical impact caused by a bearing irregularity.

This is a unique and patented method for determining the con-

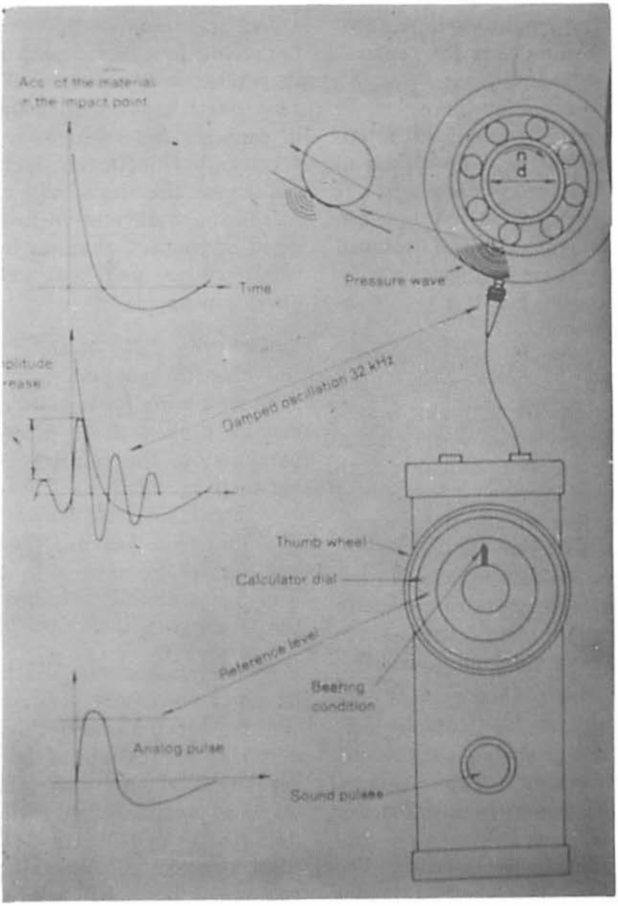


FIG. 9

dition of bearings in operational machinery without being influenced by vibration, noise, temperature, or other external factors.

The equipment in its simplest form consists of a portable instrument with a hand held probe type transducer. Adapter studs permanently mounted in the bearing housing are also available for more detailed evaluations or for permanent installations with continuous monitoring.

Bearing breakdowns can be extremely expensive due to production losses. Bearings can be replaced prematurely if their condition cannot be accurately monitored. It is, therefore, desirable to systematically or continuously check bearing conditions and forecast the optimum time for replacement.

The Shock Pulse Method of measuring anti-friction bearing operating condition was developed in Sweden about ten years ago. It was a cooperative effort between SPM Instrument AB, who designed and manufactures the instruments, and the largest bearing manufacturer in Sweden.

The Shock Pulse Method is presently being used to spot check bearing conditions in many industries throughout the world, including the automotive industry. Both portable spot check and continuous monitoring instrumentation provide advance warning of incipient bearing failure. Newly installed or replaced bearings are also tested to insure proper installation which results in maximum possible life.

Basic Theory

The Shock Pulse Method indirectly measures the velocity in mechanical impacts. The pressure wave (shock pulse) is initiated, for example, when a ball in a bearing passes a surface irregularity. The theory behind this method is not the academic shock theory taught at technical institutions. The reason is that this method is based on the events occurring in the material in an extremely short time period (typically a few microseconds) after the first particles of the colliding bodies have come in contact. This time period is so short that no noticeable deformation of the material has yet occurred.

Let us suppose that one body is moving in a linear path and that it collides with another. When the first particles of both bodies come in contact, there will be a particle acceleration, infinitely large. Subsequently, the shock will cause an increasing deformation around the point of contact, changes in motion relationships, and heat and sound development.

With the SPM Method, the initial particle contact is analyzed. This maximum particle acceleration can be proven to be directly proportional to the relative velocities between the bodies (termed Phase 1). It can also be proven that in a rolling type bearing the relative velocity in the case of a damaged bearing is directly proportional to the damage in the bearing.

Shortly after the initial compression wave has been set up in the material, deformation of the material occurs and it is this deformation which is normally measured by standard vibration techniques (termed Phase 2). In the SPM System, a pieze electric accelerometer is used, which has an inherently high frequency response. This allows the system to be responsive to the instantaneous compression wave (impulse) which ignores the later material deformation. This transducer is tuned mechanically and electrically to have a resonant frequency of 32 kHz, greater than that present in normal machine designs. The particle acceleration sets up a damped transient oscillation in the accel-

erometer at the resonant frequency. The initial amplitude of the transient can be shown to be directly proportional to the instantaneous impact velocity (V) where the transducer output amplitude (A) is a function of the velocity (V).

Although the SPM Method does not give any absolute bearing assessments, but rather bearing operating condition, values can be correlated to known bearing damage. With the aid of considerable statistical material, established in part in conjunction with bearing manufacturers, it was possible to relate the transient maximum value to the conditions in a bearing. In the SPM Method, this maximum transient value is termed "measure shock value," and is expressed in decibels (db). The relationship between the measured shock value and bearing operating conditions is in accordance with the following:

> "A properly mounted and undamaged bearing, running under normal operating conditions, will emit randomly occurring shocks at dBN readings between O-10. At decreasing dBN values, the rate of occurrence of the shocks will increase rapidly."

Undamaged bearings which are lacking lubricant or are improperly installed (housing out of round, too tight a fit or improper alignment) will give dBN readings between 15-25. At decreasing dBN values, the rate of occurrence of the shocks will increase rapidly.

Bearings with damage in raceways or balls (rollers) are normally characterized by randomly occurring shocks giving dBN value readings greater than 35. At decreasing dBN values, the rate of occurrence of the shocks increases slowly at first, but, at low dBN values (between 5-15), the increase becomes rapid.

Note: In some cases, high dBN values may have other causes than damage in the bearing itself. This can normally be determined by interpreting the rhythm and rate of occurrence of the mechanical shocks.

The relationships are color coded on some instruments with the colors green (good), yellow (caution) and red (noticeable damage).

Selecting the Point For Measurement

As originally developed, it was necessary to drill and tap the bearing housing and install a suitable adapter. When using the portable instruments, a quick disconnect transducer is attached to this adapter. A permanent transducer can be used for permanent installations. A recent development allows the use of a probe type transducer without installation of adapters. This permits measurement of bearing condition by simply holding the probe against the bearing housing.

It is important to remember that the shock pulses being measured by the SPM transducer are propagated ultrasonically through the bearing housing. Three general conditions should be satisfied in

selecting a suitable point for measurement for optimum sensitivity.

1. In the case of bearings in excess of 3-inch shaft diameter, the measurement point should be in the loading zone.
2. There should be as few material interfaces, joints, or outer covers between the bearing and the point of measurement as possible.
3. There should be a straight ultrasonic path.

Uses

Because of the empirical data developed in assessing SPM equipment in the measurement of numerous bearings, the actual operating condition of a given bearing can be determined with a high degree of accuracy. This allows measurement from the time of installation until the time of recommended replacement. This provides several obvious advantages over other types of bearing measuring equipment.

Some uses of the SPM System are as follows:

1. Checking the correct installation of a bearing either on startup or replacement.
2. Providing sufficient time for scheduling of replacement.
3. Extension of safe working life.
4. Maintaining the life history of a bearing's condition.

Equipment Available

The instruments and equipment available operate on the described principle of using a transducer to determine the maximum value of a transient oscillation. Instruments include portable bearing testers and a continuous warning system. These are described as follows:

SPM Instrument Type 43A

A hand held version in which the operator dials in speed and shaft diameter. As the transducer signals are processed in Model 43A, the shock wave caused by a bearing defect is transformed into analog electrical pulses. These pulses are then compared to a threshold level manually set with a thumb wheel. Damage exceeding the threshold level will cause short sound pulses of constant volume, the frequency of which is an indication of bearing condition. The threshold level is then adjusted until no sound pulses are heard, i.e., the time between successive pulses is longer than 10 seconds, with the use of the hand-held probe. The bearing operating condition is read directly from the dial. Model 43A can be used either with the adapters and quick disconnect transducers or with the portable hand-held transducer.

SPM Warning Monitor Type 32 (Figure 10)

This is a complete, modular test system for providing a warning of a pre-selected bearing condition. A variety of components is available depending on bearing location, ambient conditions, special conditions, etc. In this system, a permanently installed transducer is used. Transducer signals, indica-

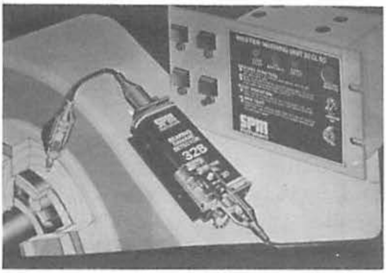


FIG. 10

ting bearing damage, are processed in a bearing damage detector. The level of this detector is pre-selected, normally toward the end of the caution yellow zone. When the measured value of the bearing exceeds the preset detector level, an alarm is given. Safeguards are built into the system to avoid false alarms and make the system virtually failsafe.

Conclusion

Condition monitoring of bearings will give increased security against unplanned machine shutdown. The SPM System will detect incipient damage so that necessary measures can be planned well in advance and carried out during a scheduled machine shutdown. This feature is of great importance in the process industry which has few scheduled shutdowns and where any extra shutdown may cause considerable losses in production.

In many more cases than the above mentioned, the SPM method has proved to be extremely profitable and it is now recognized as the best means to monitor bearing condition. The user is protected against surprises caused by bearing damage and resulting production and efficiency losses are reduced to a minimum.

C — Evaluation of tools available for grading and classifying jumper cables

Most locomotive shops and maintenance facilities that test jumper cables use a testing device that is built in shop to test cables for continuity, short circuits and grounds. Various types of button switches, lights, and meters are used in assembling this device.

Some were built with a minimum of parts and simple operation. Other shops built more elaborate testers that even had a motor-driven camshaft with arms to hold the cable and keep it moving in an up-and-down motion, to simulate actual road conditions of a cable between two locomotives, while the test for continuity and short circuits is being made.

Power Parts Company furnishes a jumper cable tester featuring automatic testing (Figure 11).

After the cable is plugged in and the start button is depressed, each wire is automatically tested in sequence and loaded to 15 amps

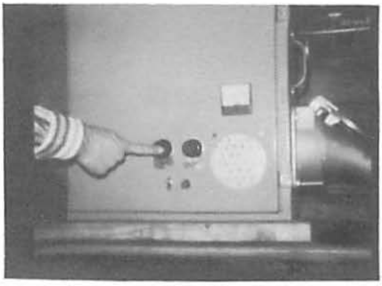


FIG. 11

d-c. As each lamp lights, an ammeter reading of 15 amps must be indicated.

If a wire is grounded, a buzzer will activate when the cycle is started and when the tester reaches the grounded wire, the indicating light will not illuminate. A short circuit is indicated by two lights activated at the same time.

If the cable is wired wrong, the lights will not be indicated in proper sequence. The tester has a separate circuit that will test all the functions of the tester to insure proper operation.

D — From Manufacturers

1. Electro-Motive Division
   a. Cylinder head pot resurfacing tool (Figure 12)

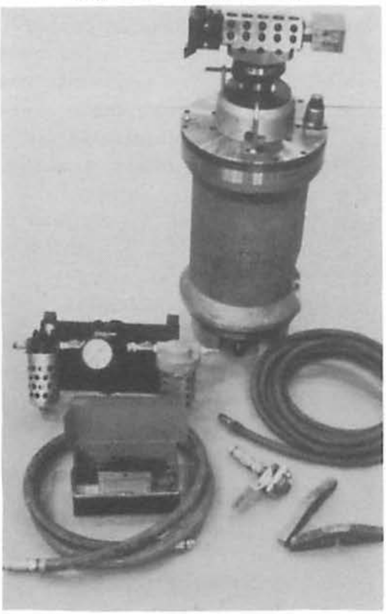


FIG. 12

Under normal service life, the engine crankcase cylinder head retainer is subject to wear. This wear rate can be kept to a minimum if the customer follows EMD recommendations as to regular retorquing at yearly inspections and by having the correct torque applied at power assembly replacements. The retainer wear occurs primarily around the inboard half of the head retainer between the 12 o'clock and 2 o'clock positions.

When a retainer wear step is found to exceed .010 in a running engine, it is recommended that the head retainer be resurfaced. Up until this time, this was a problem as the customer did not have a tool that would do the job quickly. EMD has developed a gauge, part No. 9320750, for measuring retainer wear step.

At the request of their customers, EMD has developed a crankcase cylinder head retainer resurfacing tool, part No. 9509391. The tool is so designed that a head retainer can be resurfaced with a minimum of time and cleanup. The tool weighs approximately 230 lbs. and can be installed in an engine with the same equipment a customer uses to install a "mini-power assembly."

Due to wear on the lower cylinder liner insert, it is desirable to replace the liner insert with a new insert and clean up the upper pilot before the machine operation takes place.

Listed are the steps required for tool setup and cutting:

1. A minimum of 90 p.s.i. house air pressure is required. An air regulator, supplied with the tool, reduces house air to 50-60 p.s.i. for correct tool speed. The regulator has a built-in filter and oil supply to the tool air motor. The oil supply may be adjusted to one drop of light machine oil every 30 seconds or as needed.
2. Lower the cylinder head retainer cutting tool into the engine crankcase at the same angle as a power assembly.
3. Lock the upper end of the tool by turning a nut which operates a self-centering cam locking system. Lock the tool at the lower pilot with the supplied two locking bars. (These two operations require approximately 10 minutes.)
4. Cover exposed water hole and surrounding area for ease of cleanup.
5. Position the cutter over the surface to be cut and adjust to .001 or .002 clearance. The cutting head is then retracted and adjusted for the required depth of cut (.003 to .005).
6. Rotate the head for freedom of movement and then apply pressure, locking pin in head travel.
7. Turn on air pressure. Tool will shut off when the O.D. of the crankcase cylinder head retainer is reached.
8. If the retainer does not clean up with the first pass, retract cutting head and adjust cutting tool for second pass.

The cutting tools are "throw-away" type, with six cutting surfaces. The tool service life is expected to be four cylinders per cutting surface.

A shipping container has been fabricated to hold the tool, air hoses, regulators and cutters. The total weight of the assembly is approximately 300 pounds.

b. New Tools for Camshaft Gear Train and Housing Assembly

Stubshaft Bracket Application

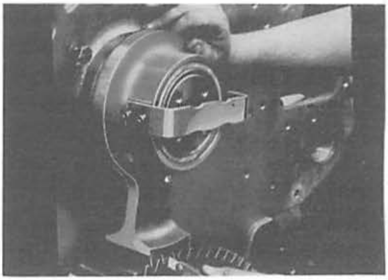


FIG. 13

1. Inspect the stubshaft bracket rear surface for burrs and wipe clean, making sure all oil passages are clean and free of dirt.
2. Install two temporary locating pins into the idler gear stubshaft bracket mounting holes in the crankcase end plate.
3. Install the stubshaft bracket in position and apply the three vertically centered ½" - 20 mounting bolts with hardened washers. Finger tighten the mounting bolts.
4. Apply the idler gear gauge (File 768) to the No. 1 idler

gear stubshaft and place a feeler gauge between the idler gear gauge teeth and the crankshaft gear teeth to check the gear backlash which is specified in the Service Data at the end of this section.

5. If the backlash is not within limits specified, gently tap the stubshaft bracket with a brass hammer until it is in position to obtain the proper backlash.

   CAUTION: Do not tap on machined surfaces of the stubshaft bracket.

6. When the stubshaft bracket is properly aligned, tighten the bottom bolt to the proper torque and re-check the backlash.

7. Apply an idler gear stubshaft to camshaft stubshaft gauge (File 769) and check the dimension between the No. 2 idler gear stubshaft and the left bank camshaft stubshaft making sure both stubshafts are wiped clean. Gauge must indicate less than 0.005".

8. If the dimension is not within limits, gently tap the stubshaft bracket until it is properly positioned.

   CAUTION: Do not tap on machined surfaces of the stubshaft bracket.

9. When the stubshaft bracket is properly positioned, tighten the top and center mounting bolts to the proper torque and recheck the backlash between the idler gear gauge and the crankshaft gear.

10. If the backlash is not within the proper limits, the three vertical mounting bolts must be loosened and steps 4 thru 9 repeated.

11. Remove the idler gear gauge and apply the remaining stubshaft mounting bolts and washers.

12. Remove the two temporary locating pins and apply the two mounting bolts and washers. Then tighten all mounting bolts to the proper torque.

13. Ream the two dowel holes with a 0.494" tapered reamer and a 0.4998" + 0.0002" bottoming reamer while using cutting oil.

    NOTE: If dowel holes in idler gear stubshaft bracket do not align with holes in crankcase, drill and ream for oversize dowels as required to produce full circumference fit. See parts catalog for listing of oversize dowels.

14. Use an air hose to blow chips and oil out of the dowel holes.

15. Insert 5/16"-24 bolts approximately 12.70 mm (¼") into the dowel pins.

16. Place dowels in dowel holes of stubshaft bracket and drive into crankcase end plate.

17. Torque the dowel bolts in groups of three or less.

18. Using a No. 1 stubshaft to No. 2 stubshaft gauge (File 770) check parallelism between the No. 1 and No. 2 stubshafts. Take one indicator

reading with gauge as close to the stubshaft bracket as possible and the other reading with gauge near the end of the No. 1 stubshaft. Dial indicator readings must be within 0.004".

Camshaft Housing Alignment Gauge

A gauge for proper alignment of camshaft housing is available from EMD and is referred to as File 771 in the 645 E3 Turbocharged Engine Manual. To align the housing:

1. Apply camshaft drive housing with proper gasket and sealer on mounting surface free of burrs or dirt and snug down several bolts to hold it in place.
2. Install a locating pin in each side of housing to act as positioning points for dial indicator.
3. Install the camshaft drive housing alignment gauge on left bank camshaft stubshaft and sweep left locating pin. Housing is properly aligned when an .008 to .010 reading is obtained on the indicator.
4. Repeat this step on right bank stubshaft.
5. If housing is not properly aligned, place a wedge between camshaft stubshaft and housing and drive in with brass hammer to move housing. Remove wedge and recheck alignment.
6. When properly aligned, ream and dowel holes in housing or drill and ream to oversize if necessary, and complete installation of housing.

The procedure for accomplishing alignment of stubshaft and housing on a blower type engine is the same; however, the gauges used are different. Gauges are identified in EMD Engine Maintenance Manual by File No.:

— No. 1 idler gear to crankshaft gear backlash: File 768

— Alignment gauge idler gear to stubshaft bracket: File 769

— Gauge to check parallelism of No. 1 and No. 2 stubshaft: File 773

— Blower stubshaft alignment gauge: File 775 for 8 and 16 cylinder, File 776 for 12 cylinder engines

— Camshaft drive housing alignment and gauge: File 774.

2. General Electric
   a. Collapsible Overspeed Link Compressor (Figure 14)

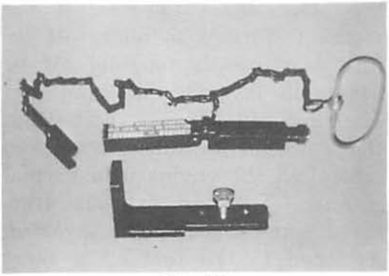


FIG. 14

When setting racks on the General Electric diesel engine, it is necessary to manually compress the overspeed link. The governor power piston must also be raised to exactly 0.344 inch gap, as measured with a gap gage.

Previously, GE has recommended use of a simple tool, essentially consisting of a heavy piece of angle iron with a large bolt through it. After securing the side of the angle to the governor drive gear box, the large bolt is screwed upward until the link is compressed and the power piston is in proper position. This tool worked well, providing the mechanic remembered to remove it before starting the engine. If he forgot, extreme engine overspeed was highly probable. The tool could not be removed quickly in case of emergency.

General Electric is now offering a similar tool, but with the large bolt replaced by a shorter bolt and a collapsible link. The latter has a chain and grab-ring attached to it, as well as a gap gage.

Installation and regular use of the tool is much the same as for the older one. However, if the mechanic forgets to remove it before starting the engine, all he needs do is pull the grab-ring. The link will collapse, permitting the governor to take over speed control of the engine in a normal manner. Thus an extreme overspeed can probably be avoided. Attached to the tool by a short chain is the 0.344 inch gap gage. If desired, the user can tie a rope or longer chain to the grab-ring for greater flexibility.

b. Air Motor for Barring-over the Engine (Figure 15)

For the past several years all new General Electric diesel engines have been equipped to bar-over at the governor drive gear box. This feature replaced the earlier barring-over arrangement at the free end cover. The engine can now be barred-over manually with a one-inch drive ratchet handle. Alternatively, the same pneutorque air wrench used for tightening cylinder hold-down bolts can be used.

Newly available is a lighter-weight, lower-cost pneutorque air motor selected specifically for engine barring-over. The motor part is identical to that on the cylinder hold-down bolt wrench, but the gear reduction has been omitted. This motor has plenty of torque to bar the engine, but not enough to tighten cylinder bolts. Neither will it fit the reaction plate used on top of the cylinder, so it can't be used wrongly in that application.

In addition, a special valve and 20-foot control hose is available for use with either air motor to permit control of the barring-over from a remote location, such as when aligning the alternator or when working on bearings at the far end of the engine. At the same time the governor drive gear box was modified to accommodate barring-over, the engine timing marks were moved from the free-end hub to the right-bank camshaft gear. They can be viewed through a window in the gear box. An electrical interlock prevents cranking the engine whenever the cover is removed to install a barring-over tool.

c. Preturbine Temperature Measuring Kit

Temperature of the exhaust gas entering the turbocharger will reliably indicate the condition of many parts on the General Electric diesel engine and its supporting systems. Abnormal pre-turbine temperatures — either too high or too low — signal that maintenance is required.

General Electric recommends use of this preturbine temperature measuring kit. It includes a direct reading digital instrument with three-digit display in degrees Celsius. Range is -50° to 999° C. Chart on the back of the instrument provides quick conversion to degrees F.

The instrument is powered by a throwaway 9-volt battery and is calibrated for use with type K thermocouples (Nickel - Chromium vs. Nickel - Aluminum.) Included with the kit is a temperature probe made to fit the adapter on the exhaust manifold (½ - inch pipe thread) and thermocouple extension wire.

d. Engine Speed Measuring Kit (Figure 16)

Accurate measurement of engine speed is an important element when trouble-shooting a locomotive. This is not easy to do mechanically with any degree of precision. When the tachometer drive speed is measured accurately, it must be divided by 1.486 to derive crankshaft speed on a GE engine. This arithmetic, too, can lead to error.

A new speed measuring kit resolves both these problems. Used with the digital multimeter previously described, crankshaft speed can be checked to 4-digit accuracy.

The necessary electrical signal is provided by a pulse generator which mounts directly to the tachometer adapter on the governor drive gear box. Output from the pulse generator is fed to a frequency converter, which in turn plugs into the digital multimeter. A switch on the frequency converter permits reading crankshaft rpm directly or, if desired, the switch can be thrown to read pulse generator rpm. The frequency converter also uses a 9-volt battery for power with a test switch to indicate battery condition.

e. Digital Pyrometer (Figure 17)

When mounting a pinion or hub on a tapered shaft, proper advance must be achieved if the equipment is to operate successfully. Too little advance will result in a slipped pinion or hub. Too much advance may result in a split pinion, or at least will make later removal extremely difficult. To attain proper advance, the pinion or hub must be heated to the specified temperature differential between the piece to be mounted and the shaft. Doing

FIG. 15

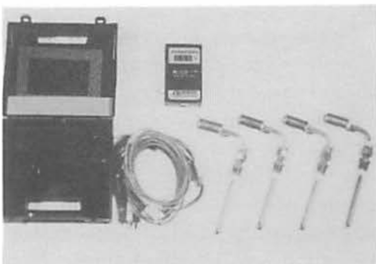


FIG. 16

FIG. 17

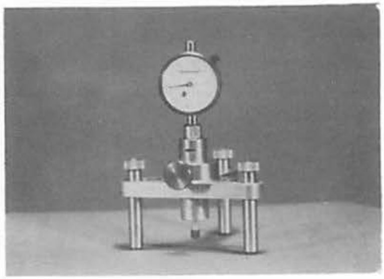


FIG. 18

FIG. 19

FIG. 20

this requires accurate temperature measurement of both components.

As with many other measuring devices, pyrometers are now available with digital readout. General Electric has evaluated and recommends the pictured digital pyrometer kit. Complete with a variety of adapters for different type measurement, this instrument will provide 4-digit accuracy, with readout in either degrees F or degrees C at the flick of a switch. Temperature measurement range is 0 to 2500° F or 0 to 1600° C.

Temperature readout is by four LED's. Power is provided by four rechargeable size "C" nickel-cadmium batteries. While they should never require replacement, that can be done with little difficulty. Low battery warning indicates recharging is required with the furnished charger.

f. Pinion Advance Gage (Figure 18)

As stated, when mounting a pinion or hub on a tapered shaft, proper advance must be obtained for successful operation of the equipment. The amount of advance depends upon the temperature differential between the shaft and the component being mounted, as measured with a pyrometer or other accurate device. Good craftsmanship requires double-checking the advance with some type of gage preferably utilizing a dial indicator for accuracy and ease of reading.

The type of advance gage commonly used in motor shops for pinion mounting has had two legs which bear against the side of the pinion with the dial indicator shaft extension midway between them. This type gage works well in the hands of a skilled operator. However, it is inherently unstable and will produce an erroneous reading if not held absolutely parallel to the shaft centerline.

General Electric now recommends an advance gage with three legs arranged in a triangle. These bear against three equidistant points on the side of the pinion. The dial indicator shaft extension is near the midpoint of the three legs. With this arrangement needed skill on the part of the operator is reduced and readings are highly repeatable, since the device is inherently stable.

g. Gear and Pinion Tooth Profile Gages (Figure 19)

Axle gear and motor pinion tooth profiles should be checked periodically to determine if excessive wear has taken place. As is well recognized, excessive wear on these components will cause quickly progressing damage to traction motors from vibration.

General Electric now has available gear and pinion tooth profile gages for all popular sizes of gears and pinions. Made of brass on an NC-guided machine, each is identified with the gage number and the gear or pinion with which it is to be used.

In use, the gage is set on the tooth profile, then a narrow (⅛-inch wide) feeler gage is used to determine the amount of wear. Limits are given in Maintenance Instructions.

IV. UPDATE ON WHEEL TRUING

a. Wheel Contouring Machine (Figure 20)

This is a portable wheel truing machine manufactured by the Independent Machine Company of Gladstone, Michigan. Operation requires the use of a 300 amp d-c welder and two 25-ton jacks. The set-up procedure is as follows:

Position wheels on the rail so the joint bar is behind the wheel to be worked on. Remove the brake rigging from the truck including the outboard hanger, brake head adjuster and straps. This is accomplished by removing the bolts located at the top of the outboard hanger and bottom of the inboard hanger. This unit should be kept intact. Place the two 25-ton jacks under the traction motor support bearings just past the axle on the motor side. This will provide adequate support and eliminate slack. Be careful to place the jacks so they will not punch a hole through the oil reservoir and cap. Raise the jacks until the wheels clear the rail by one inch, then stabilize the truck with adjustable poles. To connect the motor, couple A and FF together and connect the 300 amp welder to AA and F. If rotation is wrong, change FF to F to reverse direction. Place the wheel truing machine on the rail in front of the wheel to be turned and place leveling jacks on the inside of the pit. Now adjust the jacks to level base of the machine with the floor. Put lock bolts and clamps in place. To level and secure the truing machine, put the adjusting pole from opposite rail to the machine edge and adjust to hole spread, then tighten the clamping bolts and adjust pole securely.

The cutting tool has four inserts, one on top of the other on each side. When putting inserts in, be careful to keep the area clean as a small chip will break the insert when the holder is tightened. Adjust the tool to cut the most amount of metal from the wheel. Start rotation and engage the tool, maintaining the feed rate to keep wheel speed at 400 to 600 feet per minute. The turning operation produces shavings which are sharp and extremely hot. Care should be taken to avoid injury.

This committee has not had the opportunity to observe the machine first-hand, but solicited comments from several railroads that have purchased the equipment. Replies were received from ten of these users. Two had not used the machine and could offer no evaluation. However, seven railroads reported very good results and substantial savings. This was attributed to the avoided costs of removing wheels, shipping them to an outside concern, having them turned, shipped back, and re-assembled. One user complained of excessive noise and the possibility of turning an egg-shaped wheel.

A pair of wheels can be turned between three and eight hours depending on the metal to be removed. The amount of time required and the quality of the work depends on the craftsmanship of the operator, as the flange is cut free hand. This machine is a valuable tool to short-line industrial railroads or outlying terminals from major roads. These users find it more economical to turn the wheel under the locomotive than to dismantle and ship to another terminal for truing.

V. CONCEPTS IN STREAMLINING READY TRACKS FOR LOCOMOTIVES

For the Mechanical Department the single activity which represents the greatest volume of work, in sheer number of units, is the daily servicing and inspection of locomotives. In any 24-hour period all mainline freight locomotives are fueled, sanded, serviced and inspected. It is the obligation of the Mechanical Department to perform this work in the shortest time possible to keep locomotive out-of-service time to the bare minimum. Locomotive out-of-service time can only be reduced by providing an unobstructed flow pattern from the time the locomotive consist is cut off the train until it is serviced and re-applied to an outbound train. The key to performing this daily work expeditiously is a flow-through process which allows the work to be accomplished on a one-step basis. The locomotive service track as defined in this article is the facility which permits the effective accomplishment of this work.

The work activity at the service track includes the following three items:

1. Cleaning of the locomotive exterior including the running gear and fuel tank.
2. Fueling, sanding, servicing and inspection of the locomotive.
3. Make-up of locomotives into outbound consists.

The locomotive wash facility consists of two sections. The first section is an automatic spray wash to clean the exterior of the locomotive car body. This section consists of five spray arches which are actuated by the locomotive as it passes a switch mounted on the rail. The first spray arch applies a pre-rinse which cools the car body surface. The second spray arch applies an acid solution which is the primary cleaner in the process. The third arch applies an alkaline solution which neutralizes the acid solution. The distance between the second and third arch is a function of the reaction time for the acid cleaner and the speed of the locomotive consist through the wash facility. The fourth arch is a high-pressure, low-volume rinse which mechanically knocks off dirt which has been loosened by the cleaning agents. The final arch is a low-pressure, high-volume rinse which washes away all loosened dirt from the car body.

The second section of the locomotive wash facility is a drip-dry area outbound from the automatic spray arches. Here the excess water drips from the locomotive before it enters the servicing process. Also supplemental cleaning of the running gear and fuel tank can be accomplished in compliance with governmental regulations.

The locomotive service track should be designed to permit the fueling, sanding, servicing and inspection of locomotives on a one-stop basis (Figure 22). In addition, the locomotive service track is designed to provide the locomotive with lubricating oil, treated engine cooling water, and traction motor support bearing oil. All services are piped from a centralized distribution point with conveniently located outlets for 100% coverage on the locomotive service track. The between-rail pit should be 4' 6" deep to provide adequate clearance for walking under the locomotive but not too deep for inspection of the traction motor and running gear. Within the pit are lights for illuminating the underside of the locomotive, and outlets for traction motor support bearing oil, hot water, compressed air and 110v a-c electrical receptacles. Suction inlets are provided for extracting both fuel and lubricating oil from the locomotive.

One railroad has designed its locomotive service track to do minor repairs in lieu of sending the locomotive to the shop for such work. A single stub-end track has been provided for this work and the warehouse has been stocked for all necessary materials to accomplish minor repairs. When possible, items such as changing lubricating oil filters, fuel filters, brake shoes and traction motor brushes should be done while the locomotive is being serviced. This greatly reduces the out-of-service time for minor repair work.

The locomotive service track should also include a complete fuel, water and lubricating oil laboratory. In addition to the normal lubrication oil tests for fuel dilution and viscosity, the lab should also have an oil spectrometer. The spectrometer is used to detect the amount of contaminants (in parts per million) for ten elements which might appear in lubricating oil. The analysis of the oil sample indicates if potential failures are imminent based on the rate at which certain contaminant levels increased. To guard against a potential failure on line, the oil sample is taken and analyzed before the unit is released on the ready track (Figure 23).

Locomotive reliability and availability can be increased by incorporating the following concepts in design of any new locomotive service track:

1. Provide one-stop servicing of locomotive consist so that fuel, sand, lubricating oil, engine cooling water and traction motor support bearing oil can be simultaneously applied to the locomotives without having to spot and respot the locomotive consist.
2. Provide a work environment where the inspection process can be more effectively accomplished including the provision of the necessary tools, equipment and facilities to do the work.
3. Do as many minor repairs at the locomotive service track as possible to avoid sending the unit to the shop, as long as the repair work does not block the servicing of other locomotive consists.

The expeditious processing of locomotive consists through the high-volume daily servicing process is the single most important

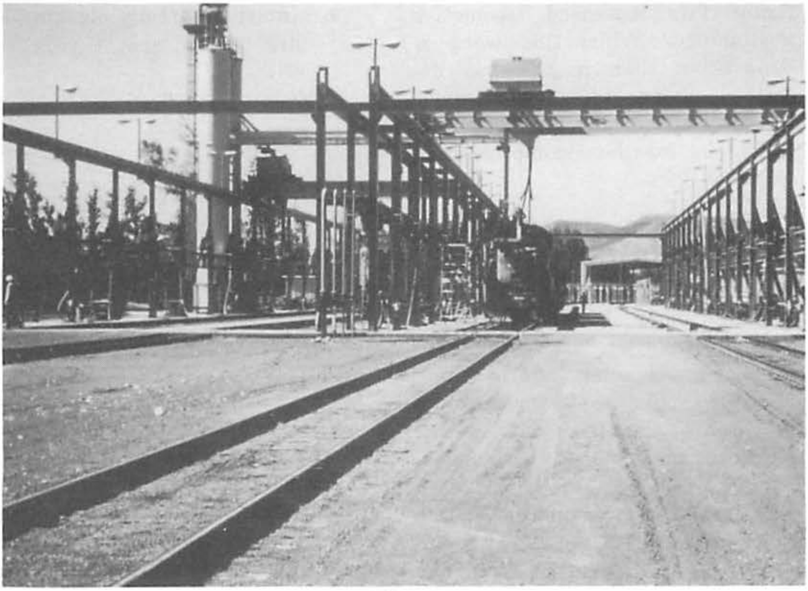


FIG. 22

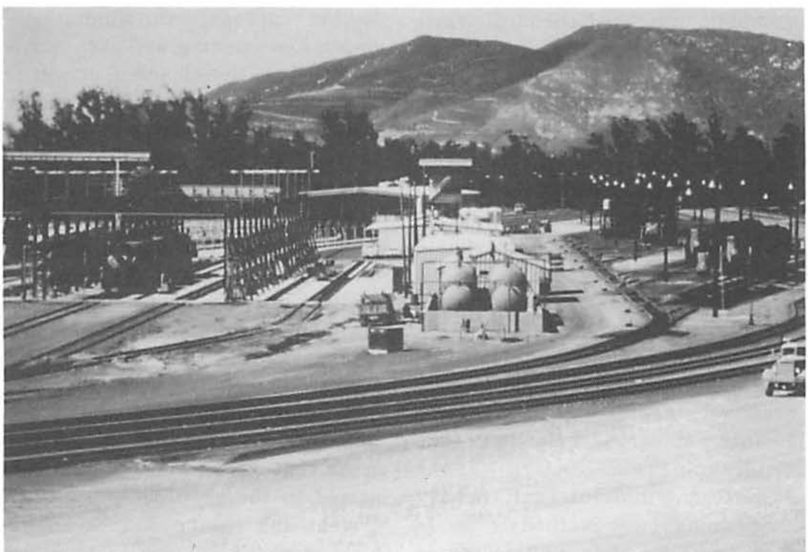


FIG. 23

factor for increased locomotive availability. When this work is done other than in the way described above, the out-of-service time is considerably higher than it should be for the locomotive road fleet.

VI. UPDATE—LOCOMOTIVE CLEANING AND WASHING EQUIPMENT

The primary objective in the design, installation and use of a locomotive cleaning and washing facility should be to produce an acceptably cleansed unit in the quickest and most economical manner.

Federal safety standards dictate that locomotives must be maintained clean to prevent fires and injury to personnel. EPA's Clean Waste Act prohibits industry from dumping untreated chemical waste water into streams.

Ideally, the facility should provide year-round automatic cleansing of locomotive carbody and trucks.

Recent installations are housed in buildings that do permit year-round usage even in cold climate conditions.

A survey of facilities indicates a trend for "spot" system installation where locomotive cleansing, dry and wet, is performed in progressive stages:

1. Internal carbody cleaning (dry cleaning)
2. External and internal carbody cleaning (wet method)
3. Trucks and undercarriage cleaning (wet method)

a. Internal carbody cleaning—dry method spot 1 (Figure 24)

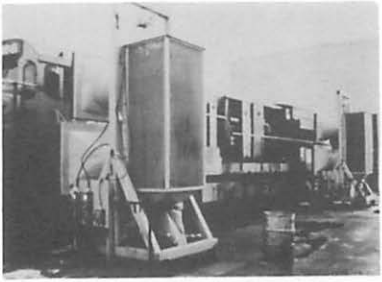


FIG. 24

Cab and underfloor cleaning can be expedited by use of a portable or stationary adjustable suction device usually consisting of two 36" diameter fans enclosed in a metal housing equipped with filters and detachable trash containers. This device can be moved up to the carbody cab window and underfloor opening and then moved away when the cleaning operation is completed. The device must be provided with adjustment features that provide positive sealing against the locomotive carbody.

After the locomotive unit is spotted the suction device is moved and adjusted against the cab. Generally a rubber boot outlines the perimeter of the hoods which provides sealing against various cab styles. The cab access door and under-cab access door on the side opposite are opened to provide cross ventilation. A blow gun, connected to the shop compressed air system and equipped with an extension nozzle is used to blow out dust, dirt and other debris from the

difficult to reach areas. The debris are picked up and carried to the interior of the suction fans' housing. When the fans are turned off, the captured debris drops into the detachable waste containers and does not escape into the shop area. The small particles of dust and debris are trapped on the filters mounted in the filter wall behind the suction fans.

Electrical cabinets, generators, etc., are blown clean at this spot location.

b. Internal and external carbody cleaning—wet method spot 2 engine running. The battery is washed and serviced. Excess supplies and any large size paper or debris not removed by suction fans are taken off.

The carbody, engine room, engine, compressor compartment, compressor, nose hood section, toilet, walkways, cab interior are sprayed manually with carrier specified cleaning compound, usually premixed.

Areas of stubborn, hard-to-remove grease and dirt are brushed to loosen dirt build-up.

Cleaner is applied with specially equipped low pressure nozzle guns, with orficed spray nozzle for proper flow rate and spray pattern.

Generally an alkaline cleaner is used and applied at a pressure of 35 p.s.i.

Some systems use the alkaline cleaner in a straight forward application and others use special foaming equipment to apply the cleaning solution (Figure 25).

FIG. 25

All systems require some manual brushing and some specify a complete brushing of the carbody exterior at specified inspection periods.

After the cleaner is applied and the required brushing operation is completed the areas involved are rinsed using a high pressure (usually 500-700 p.s.i.) rinse gun equipped with a long extension. Hot water rinsing, if available, is desired. The rinse gun is equipped with an orficed nozzle of usually 7½ gallons of rinse water per minute flow.

It is absolutely essential that means be provided to properly drain or remove the cleaner and rinse water remaining in the unit carbody.

Some carriers have provided drain holes that can be plugged for normal operation of the locomotive. Plugs are removed prior to commencing the washing process and reapplied upon completion.

Other, more sophisticated systems are equipped with a central vacuum system for water removal.

The cleaner and rinse water, in some satisfactory manner, must be

removed to avoid problems such as:

— Traction motor grounding
— Main generator grounding
— Insulation failure of electrical wiring in pits and high voltage cabinet, with subsequent damage or road failures
— Hydraulic locks in the engine cylinders
— False indications of engine cooling system leaks in the combustion chambers.

c. Trucks and Undercarriage Cleaning

Truck and undercarriage cleaning is either performed automatically in conjunction with the carbody cleaning operation or as a separate function after the carbody cleaning operation is completed (Figure 26).

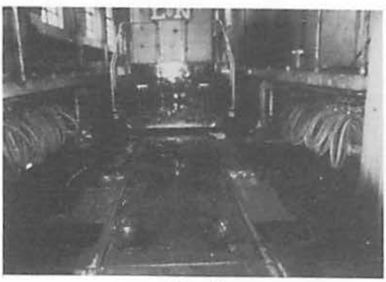


FIG. 26

Generally the cleaner, carrier specified, is sprayed on the trucks and undercarriage using an automatic spraying device traveling at a specified rate of speed the length of the locomotive unit. This same machinery is also used as the rinse mechanism to remove the cleaning solution. Cleaning solution is generally applied at pressure of 35 p.s.i. Rinsing is generally performed at high pressure, usually 500-700 p.s.i.

Frequently special attention must be given to the area below the running board (trucks and fuel tanks) and the radiator area.

A new type of washing system to be used in conjunction with diesel locomotive service facilities has been recently developed by one railroad and is now commercially available from Jaggers Equipment Company, Louisville, Kentucky, as a complete wash system. This new system incorporates several patent-pending features that will drastically change present-day cleaning of vehicles (locomotives included). This system cleans without the use of chemicals and hot water (Figure 27).

FIG. 27

This new system uses the principle of concentrating all of the water volume into one or two nozzles, thereby increasing the available impingement force at the surface being washed, even though the distance of the surface from the nozzle varies somewhat. The nozzles are reciprocated by means of an arm that is hydraulically actuated. The coverage of the spraying area can easily be changed by varying the stroke of the hydraulic cylinders. The stroke of the arms is controlled electrically by sealed proximity switches (mounted on the arms) and a selector switch (mounted on the control cabinet) with multiple contacts. The washer can be set to wash the complete carbody, the radiator area, or the fuel tank and trucks area. Since the cleaning of the fuel tank area usually involves the removal of heavy deposits of grease and roadbed dust, a solid stream nozzle is needed instead of the usual "V" Jet type nozzle used on the carbody and radiator areas (Figure 28).

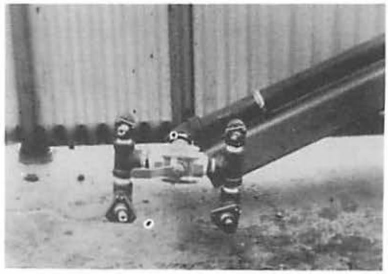


FIG. 28

A diverter valve is used to direct the flow of water from the

V-Jet nozzle to the solid-stream nozzle when required. The nozzles are mounted in a swivel socket, one nozzle is angled to the left and upward, the other nozzle is angled to the right and downward. This arrangement allows the cleaning of the different surfaces of the locomotives that are not directly in front of the washing arms.

The arm and nozzles arrangement has a broad coverage area from the lower wheel area to the top of the carbody. The two arms are independent of one another, having their own 40 horsepower high-pressure water pump units. The arms share a common five horsepower hydraulic power unit. The hydraulic unit is equipped with a tank heater, so that the wash system can be used in cold weather. The speed of the reciprocating arm can be varied by adjusting the hydraulic flow controls.

The electric control cabinet consists of the usual motor starters, disconnects and timing relays. The control station can be located at the service area allowing the washer to be remotely operated.

The control station consists of an off-on selector, washer area selector switch (carbody, trucks, radiators), and a cycle timer. The cycle timer is marked in the number of locomotives to be washed; approximately 8 minutes required per unit. Each arm sprays 70 gallons per minute at 900 p.s.i. pressure.

The most sophisticated system investigated in preparing this paper was the Aquamega Trainwashing System designed by Thorby Bros., of Sydney, Australia, and represented by Sundt Construction Company of Tucson, Arizona (Figure 29).

FIG. 29

Most of the washing equipment is supplied by Ross and White Co., of Chicago.

The concept of this plant is based on a total package including design and consultation i.e., civil engineering design and construction, architectural design and construction, chemical design and construction.

With this concept a recycling system of the chemicals and water is used.

The washing plant is designed automatically to clean a maximum of six locomotive consists in process.

The plant incorporates a towing system which is capable of moving three locomotives coupled at constant speed through the plant. A safety device is incorporated to prevent the locomotives from being removed by external forces.

A single locomotive can be washed at the same rate.

The total washing facilities are enclosed in a single building to which is attached a motor control center for automatic operation.

In the course of normal operation locomotives are made available at the feed end of the washing plant and recovered by hostlers once the washing cycle is complete.

The washing cycle begins at a pre-rinsing arch where fresh water is delivered at approximately 400 p.s.i. through the full arch of spray nozzles.

The second wash cycle incorporates an acid wash arch to provide acid soaking of carbon deposits and brushes to scour carbons and oil adhering to the top of the locomotive.

The third arch contains acid fogging nozzles to provide a second soaking, allowing time for the acid to react with carbon deposits.

The fourth arch supports a full cycle of fresh water rinsing nozzles to remove acid residues and loosened scale.

The fifth arch incorporates alkaline cleaning chemicals for the removal of greases and oils both from the top sides and undercarriage.

This is followed by a recycle water arch.

Finally a high pressure fresh water rinsing arch is incorporated for end point rinsing.

To facilitate cleaning, most high pressure nozzles are of an oscillating type automatically actuated (Figure 30). This approach en-

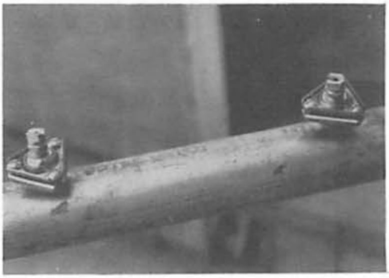


FIG. 30

sured that any grease, grime, and carbon is actively cut from surfaces which are otherwise inaccessible to mechanical cleaning equipment.

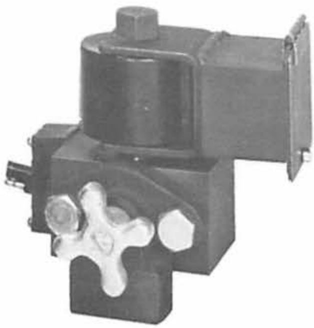
The various washing and cleaning arches are activated by tripper switches on the track.

Corrosion control of wash equipment and the building structure is assured by the use of stainless steel pumps and pipings and high-build chlorinated rubber coating to structural members. Wall cladding is a proprietary brand of precoated steel designed specifically to resist both alkaline and acid conditions.

An important feature of the Aquamega washer is the complete recycling of all the agents and water used in the process.

To this end the plant is equipped with settling tanks, skimming equipment, chemical dosing equipment, waste disposal equipment, waste collection equipment, and recycling pumps.

Particular attention has been paid to ensure that chemical losses are at a minimum. A fully inte-



PM-981 Drain Valve

PM-768 Timer

grated electronic scan is provided to register changes in chemical pH and quality. These controls are connected to chemical dosing equipment which automatically maintains the preset pH and reagent quality levels.

Concrete settling and chemical holding tanks are located external to the building. These tanks are protected by heavy duty internal epoxy linings.

The incorporation of oscillating high pressure spray nozzles is a particularly advantageous feature which allows effective cutting and lifting of otherwise tightly adhering oil and grease residues from the undercarriage components.

In summary:

1. The Aquamega Train Washing Process is ,capable of meeting the following objectives:
   a. Minimum locomotive downtime for washing
   b. Thorough and effective cleaning
   c. Automatic operation
   d. Frequent and regular low cost washing.
   e. Facility for better undercarriage inspection and maintenance
   f. The effective cleaning produced allows for ease of inspection and maintenance of undercarriage parts, particularly where crack detection inspection and breakdown inspection is involved.
2. All chemical agents used in the washing process can be recycled and maintained at a constant quality so that waste disposal can be kept to a minimum.
3. Construction of the plant is modular allowing each module to be erected easily and quickly.
4. The accommodation of mechanical brushing and high pressure jet oscillation allows for the most efficient process to be incorporated in a large plant designed to handle three locomotives at any one time.
5. The recyling process is of paramount interest in that it allows for frequent washing to be undertaken without undue cost. The savings facilitate the incorporation of regular washing as an ongoing maintenance feature. The effect is to provide locomotives which are clean, safe to operate and maintain, and on which paint coatings can be expected to provide an extended service life.
6. The combination of mechanical cleaning and high pressure oscillators allows for cleaning chemicals of lower than usual acid or alkaline value to be employed so that, in respect to the number of washings, there is unlikely to be any significant deterioration in either paint coatings or locomotive components.

In addition to the above, more sophisticated systems, there are numerous versions of locomotive cleaning and washing arrangements consisting of concrete slabs enclosed in a building, if year-round operations are enforced in cold climates or metal or fiberglass

enclosures in warmer climates or where year-round operation is not practicable.

These less sophisticated systems are equipped with spray loops type washers and rinse stations spaced at specified intervals depending on the chemicals and methods utilized.

Generally, five loops are used:

1st Loop —
Water for pre-wetting

2nd Loop —
Acid type cleaner material application

3rd Loop —
Alkaline type cleaner material application

4th Loop —
High pressure water rinse

5th Loop —
Medium to low pressure water rinse.

Some loop systems are station actuated by photo-electric cell light beams and some by proximity switches. Others are manually operated.

Some loop systems apply cleaner materials and rinse water in a straight-forward manner through orficed nozzles at a fixed delivery rate and specified pressures.

Some loop systems utilize a scrubber method of applying the chemical and rinse water through manifolds that rotate back and forth so that the fluids impinge on the surfaces to be cleaned.

Other loop systems observed employ rotating unions equipped with spray nozzles in conjunction with fixed nozzles on the loops to effect a scrubbing action to loosen the dirt load.

While most facilities use the cleaners once and pass the material on for waste treatment and disposal, there are still some who recover the cleaner materials and reuse them.

Several facilities are presently equipped with air dryer equipment to blow off and dissipate excess water left on the carbody exterior after the final rinse.

One of the latest innovations in providing a cleaner and more protective arrangement to the locomotive carbody exterior surface is automatic hot wax spray application after the final stage of the locomotive cleaning and washing operation. Strippable wax is supplied by Lutex Chemical Co., Chattanooga, Tenn. (Figure 31).

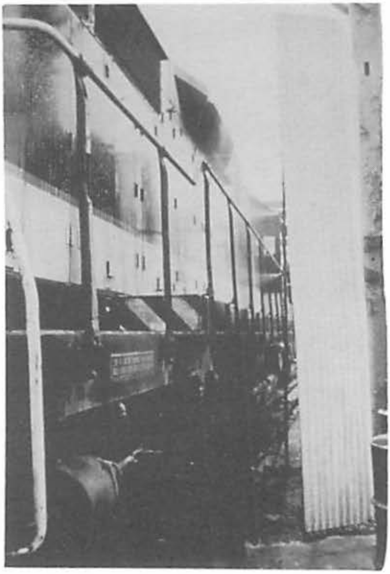


FIG. 31

This paper does not purport to furnish construction details, storage capacities of materials, engineering design or other data. These must be developed by each property to meet the requirements of its management.

In summary, there have been some innovations and improvements in locomotive cleaning and washing equipment and methods. However, there remains a great need for further development in both equipment and materials that will provide cleaner locomotives at a more reasonable expense.

VII. MICRO PROCESSOR— APPLICATION FOR TOOLING (MACHINES)

Lathes, planers, drills, milling machines and presses represent just a few of the machines that in one form or another are the backbone of industry. In the past, the quality and quantity were maintained by extensively trained machine operators. Quality of workmanship required that a machine operator be knowledgeable in all facets of his work. A lathe operator, for example, must have a firm understanding of math, the key to determining the required cutting depth to arrive at an accurate predetermined finished diameter. He must know tooling to calculate performance at different cutting depths and feeds. He must be familiar with the inherent characteristics of the machine in operation to foresee any deviations and consequently allow for them. Are there any non-linearities in the ways and can they be corrected for? What are the dimensional requirements and allowable tolerances? What must be done with feeds and speeds to produce a specified surface finish? Thousands of dollars have been wasted due to an operator's poor judgment or unconscious error.

The requirement of good judgment in operating a manual machine is evident as one compares quantity and quality of work done by a seasoned veteran versus a novice. Still, even with the best of precautions, repetition in work may cause even a skilled operator to make costly errors, errors that may be hazardous or even deadly.

With the advent of computers and digital controls, many of today's industries have changed. The accuracy, consistency and versatility of a computerized system can take the routine operations and make them automatic, in much the way an automatic transmission in an automobile has eliminated the necessity to shift gears. Human error has been minimized by creating systems that perform difficult and sometimes lengthy computations quickly and accurately; then when needed implement instructions relating to them.

The ability of a computerized system to remember data and make decisions about it via other data already stored makes it a useful tool in industry. Given the proper program, there is very little, if anything, that a computer cannot do. A lathe controlled by a computer can perform its basic duty plus monitor production, modify assembly line production schedules, order new materials, arrange billing, perform efficiency evaluations and monitor machine statistics. Most of the preparatory work on a piece such as measuring of diameters and lengths can be done before the piece reaches the machine. This means that the job requirements are finished and ready when the piece enters the machine. Some of the jobs, however, may require probing of the piece after it is loaded into the machine, for one reason or another. Either way, accuracy is kept at a minimum and time at a minimum.

In a manual lathe for reprofiling freight car wheels, the system causing the movement of a tool across the thread must be set by eye. The operator, and the company, depend upon the operator's judgment for production and quality. To perform the same function, controlled by a computer, much information must be accurately perceived and transmitted to the computer. Many measuring and sensing devices must be used to recreate for the computer the image of the wheelset. Once an adequate description of the wheelset is accumulated, the computer, via a comparative thought process, acts on the information to recreate a new wheel profile. To this point nothing physical has happened to the wheelset. Now the instruction from the master controller must be handled and executed exactly as instructed.

The most critical portion of any computerized machine is the way in which the computer perceives, and the subsequent accuracy of the device. With appropriate measuring and sensing devices, a computer can be extremely accurate. In a moveable upright boring mill such as a car wheel borer, accurate placement of the boring bar is a must. A miss by a few thousandths of an inch may waste an entire wheel. By using a high resolution measuring device (a Farrand Scale) attached to the upright, very precise positioning can be achieved. To be precise the only device that can be used to see the inaccuracy in the upright movement is a laser. When pursuing an error evaluation, multiple moves are made while a laser is used to keep track of its position. A good repeatable factor would be in the .000001 range.

Other devices have been developed to aid digital equipment in perception; limit switches, pressure sensors, specially designed optical sensors, linear induction transformers, variable induction transducers, shaft angle encoders and others. It is these devices and combinations of them that give computers their ability to keep in contact with what they are doing.

Listing the attributes of the computers in industry, other than in an office situation, is at present an impossibility, for every time man finds a situation that he

hasn't the equipment to handle, he invents or builds to suit.

However, before concluding that the computer has answered all of mankind's problems, there are many points to be considered. Reliability of associated hardware such as input/output devices (servo amplifiers, dual servo axis controllers, general purpose input/output controllers, etc.) and their ability to develop the appropriate signal for the appropriate device is required for the mechanical equipment to perform as instructed. Failure of any of the preceeding devices will more than likely cause a complete failure of the machine. However, some failures may only appear as a loss in production.

Whenever, and at whatever level, a machine is made more intricate, the requirements for maintenance are also increased. The monitoring and sensing devices on computerized lathes must perform accurately. If these devices fail to give an accurate view of their surroundings, the computer will make what appears to be erroneous moves of the machine. For a machine (controlled by a computer) to continually perform its function correctly, every component must function precisely.

In today's automated world, more and more shops and factories are changing over to computerized systems. In many situations this means that a major computer failure may close down an entire shop's production, or severly hamper it. Thus extensive maintenance must be performed at regular intervals to insure proper performance. There must be regular daily, weekly, monthly, semi-annual and annual inspections. Though the maintenance may appear to be excessive, production and quality go hand in hand with training and maintenance.

With the advent of computers controlling or at least affecting many of the everyday factors of living in the world today, it was only a matter of time until they were used in machine control and processing in the railroad industry.

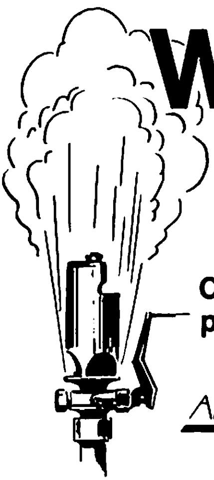
Some of the forerunners to computer control used tape to control machines that processed EMD heads thru a number of machining operations while restoring vital dimensions that measured off and punched holes along the length of a channel, angle, or beam: or that made a new locomotive axle or restored an old one to proper undersize dimensions and finish for further service.

These steps have led to more advanced control, with the latest arrangement being a computer controlled wheel handling system consisting of a fully automatic double-ended wheel loading, unloading, inverting manipulator for handling 36 and 40-inch locomotive wheels into and out of the wheel boring machine. The wheel conveyor system will bring in four-high stacks of wheels to each boring mill independently as requested by the machine control computer, then destack automatically by the manipulator. The manipulator will be fully automatic and will be integrated into the machine control computer.

The boring mill will be equipped with an automatic electronic boring bar for automatic bore sizing. The computer will take information from the axle measuring station designed to independently measure each wheelseat and the gear seat of locomotive axles. This wheelseat information will automatically be transmitted to the control computers of two wheel boring machines for automatic bore sizing. The gear seat diameter information will be transmitted to a remote digital readout in the gear storage area to assist in queing gears in proper order to the mounting press.

When the two computerized boring mills are in service, one machine will process rear end wheels while the second machine will process opposite end wheels based on the wheelseat sizes handled thru the computer from the axle measuring station.

Because of the degree of computer control involved in this overall process the amount of manual labor along with personal errors will be minimized, providing the necessary savings to warrant purchase and installation of the equipment.



NOTES

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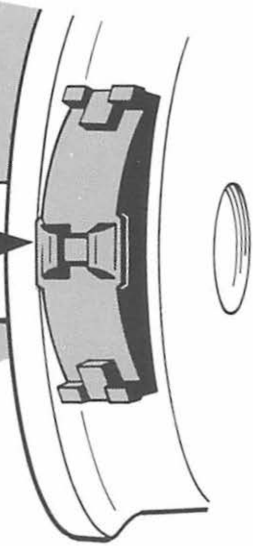

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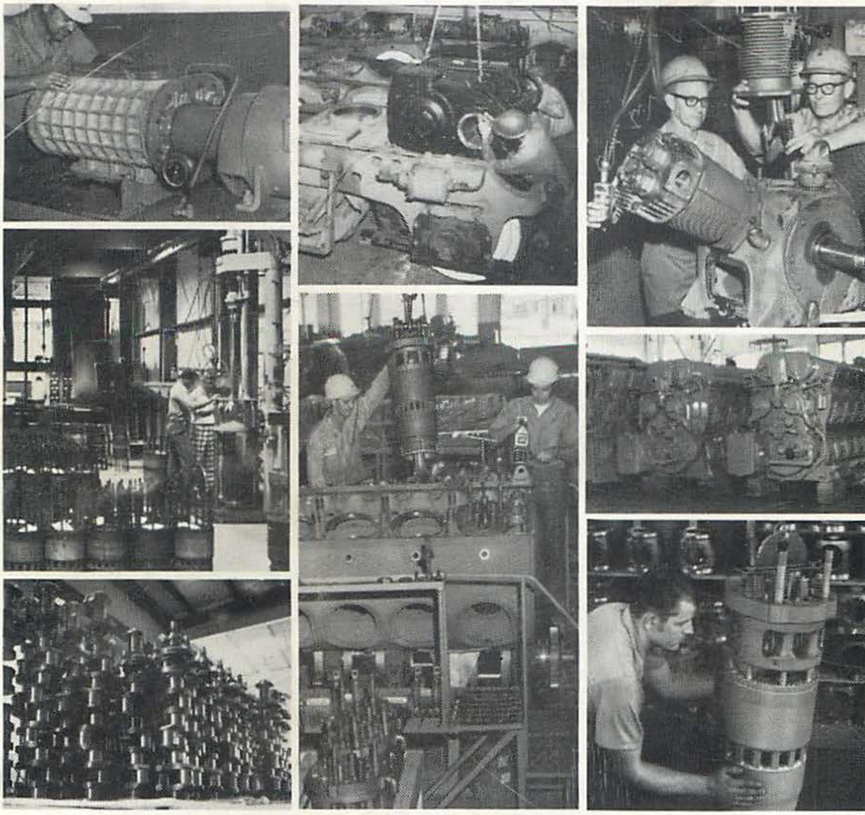

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