GENERAL DISCUSSION

CO-CHAIRMAN R. C. MCMASTER[1].—I should like to question a few of the audience and ask you to discuss the dollar volume of testing with which you are familiar. It is probably that in many industries, management does not know the over-all dollar value of the material inspected or cost of non-destructive testing. I think this may be an important clue. Probably we have not as yet recognized the scope of this problem.

MR. W. E. THOMAS[2].—I have been doing some rough figuring about the amount of money invested in material which is subjected to non-destructive testing. It is in the neighborhood of hundreds of millions of dollars, and that is as close as I will come. I am not just pulling this figure out of the air.

McMaster mentioned drill pipe which is worth about $200 for a 30-ft. joint. Each "strings" will average about 9000 ft. which would then be 300 joints times $200 or a value of $60,000 per "string." There are, in addition to the drill pipe itself, drill collars on the end of the string, which cost considerably more money.

So, we might say that a string of drill pipe may be worth approximately $75,000. I believe the latest report of the *Oil and Gas Journal* of the number of drilling rigs in operation is at least 2000. Multiply 2000 by $75,000 and you have a total of 50 millions of dollars. That pipe is inspected in the mill and in the field to locate corrosion or fatigue cracks.

But, aside from that, I roughly estimated a few industries that I happen to know something about.

I would estimate—and this is plus or minus 500 per cent again—that the probable output of locomotives per year in this country is roughly 600 million dollars. The bulk of that is subjected to non-destructive testing of one kind or another. In the operating railroads, I would say the figure would certainly be between 1 billion and 2 billion dollars, which is estimated on the appraisal value of the motive power, the locomotives, and a fairly close estimate on the number of major shoppings to which they are subjected each year. I estimate one half of a major shopping each year for each locomotive. I have the figures here, but I am not going into them in great detail.

I have some reason to believe that the total value of material inspected by non-destructive means would be 200 to 500 million dollars a year.

The important thing is not how much is inspected but the value of the inspection, as Ball and others have mentioned. What can be saved by inspection is where the dollar value should be measured.

The freight car axle that may fail may be under a car that is worth $5000. The wreck may cost—and not without too much exaggeration—a million dollars. The axle itself is only worth, perhaps a few hundred dollars.

The important thing is not the few hundred dollars itself, but it is the million dollars. That is where management's attention must be focused.

MR. JOHN SMACK.[3]—We have talked

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mostly today about testing manufactured products, since the title of the symposium is "The Rôle of Non-Destructive Testing in the Economics of Production."

There is one phase that has been skirted one or twice, but nobody has fully described the saving of production and the economics of testing machinery and equipment in the plants. That also includes the testing of railroad equipment. I can give you a few examples which, with some round figures on costs, may be of considerable interest.

For example, we have done some testing for a large paper mill. This is not an ordinary paper company, making writing paper and that sort of thing. Their equipment runs at very high speeds. Anything developing in the machinery that causes an accident really is a catastrophe. There was one accident which knocked out about 25 per cent of their production for approximately six months, and one of the insurance companies gave a round figure indicating that it cost the insurance company about three-quarters of a million dollars for that one accident.

We tested the shafting of pressure rolls, and also the shafts on Yankee driers. One particular day we found cracks in the journal shafts of a Yankee drier on both ends. That would have caused very nearly the same kind of accident as the one described.

The cost of non-destructive testing for the day was roughly $100 for the man's time and the use of the machine. But it saved a possible loss of anywhere from $100,000 up to three-quarters of a million dollars.

We have also done some testing for the mining industry. Three years ago, in May, we spent one week with one man and one machine in a coal mine, and we tested many of the shafts on the blowers, that is, the big ventilating fans. We also tested all of the crank pins and some of the shafts on the steam hoist engines. These items were very critical. If a failure should occur there it might involve the loss of lives. Some accidents had happened, but everyone had been lucky. Part of the steam engine had gone out through the wall of the building.

Three years ago we found two cracked crank pins, which were both potential accidents. A year later, we spent two more weeks, with one man and one machine at the mine. We didn't find any cracks in the crank pins or any cracks in the shafts. However, this year, they had us in again, and we spent three weeks in the same mine, of course going over a good many more shafts and other parts, and we found another cracked crank pin.

The cost of the last three weeks' testing was roughly in the neighborhood of $1200, but that one accident from the one crank pin, which would have undoubtedly occurred sometime during this coming year, would have been many times the cost of the three weeks of testing.

The same thing has applied to the railroads. The Erie Railroad, after installing a complete system of checking the axles and crank pins on the steam locomotives, entirely eliminated accidents, which, in many cases, amounted to many thousands of dollars for just one accident.

Insurance companies, of course, are interested, but not necessarily from the viewpoint of production. Some failures actually interfere with production, where the insurance companies are concerned merely with replacement of the equipment. If you have equipment which is not immediately replaceable, it is very seldom that you replace all your losses through insurance.

MR. A. F. JOHNSON.[4]—I think our biggest problem is to find what is the proper instrument to use most economically. We use Magnaflux, and we use one type of ultrasonic equipment. But maybe

[4] Inspector, Atlantic Refining Co., Philadelphia, Pa.

there is another type of test equipment, much better, that would be more applicable to our type of work. Just what it would be, I don't know. How to go about making a survey of available equipment without being snowed under, perhaps, with too much good sales talk, I don't know.

I think that is our big problem. We know what we want to do. We are doing a lot of things, perhaps, by what might be called old-fashioned methods. We have men who go out with a hammer and hit a pipe to see if it is any good. There are other ways of doing it too, more modern methods.

I think our problem is to find the right way, the most economical way. The papers have been very, very instructive. I want to compliment all the authors.

MR. PATRICK E. CAVANAGH.[5]—The development of Cyclograph test equipment for the inspection of wire rope has been going on for about eight years and field trials have been in progress for about five years.

A modification of the Cyclograph is used to perform one part of the tests, depending on the fact that the magnetic properties of steel change during failure and also change under the influence of a known change in load. The test instrument records certain magnetic properties over the length of the rope at a known load. A second recording is taken at another known load. Such tests are taken at the same known loads at periods of one week or one month. If no change has occurred in the rope, the recorded curves will coincide exactly with previous curves taken at the same loads on the same rope. Any change in the recorded pattern can only be due to a change in the condition of the rope. A continuing change at a point in the rope indicates damage. Further information regarding the damage which is occurring is shown by the spread between the two curves at two known loads taken at any one time. As damage progresses, the change in magnetic properties due to a known change in load will increase.

A running dynamometer is used in conjunction with the Cyclograph Rope Tester and records the actual load on the rope at the Cyclograph test point. This load determination is also recorded on the charts and aids a great deal in interpreting the Cyclograph charts.

If these tests indicate a continuing change in conditions at a point in the rope, that point is considered as suspicious and is very carefully inspected visually. If this suspicious point is not found to be seriously damaged, the rest of the rope will not be seriously damaged.

The Department of Mines in the Province of Nova Scotia has been inspecting the same ropes periodically with this equipment during the past few years. The equipment is mounted in a truck and inspects the ropes in all the inclined coal mine shafts in Nova Scotia. There is now a considerable backlog of data to show the performance of this testing procedure in operating mines. The Nova Scotia Department of Mines is presenting a paper on the results of this work at a Meeting of the Mine Inspectors at Wheeling, W. Va., June 6, 1950. Another paper will be presented at the International Conference on Wire Ropes in England during September.

From the point of view of this meeting, there has been one extremely interesting development during field trials of this equipment. The main purpose of developing such equipment has always been the hope that greater safety would be attained in hoisting operations. This is still the main object but it has now become evident that rope failures are not going to happen if the equipment is used in a way which also, and inciden-

[5] Non-Destructive Testing Corp., (Canada) Ltd., Toronto, Ontario, Canada.

tally, saves money. Rigid periodic inspection gives a complete picture of the progress of damage in a hoisting rope. Experience in Nova Scotia has already indicated cases where slight changes or repairs to equipment will eliminate some of the causes of rope damage. This will naturally increase rope life and be profitable.

The possibility now arises that with such an inspection method available to examine every part of the rope, it may eventually be possible to discard ropes when they are known to be seriously damaged, rather than discarding them after an arbitrary time limit. From the point of view of management, this is now the major interest in this type of test. It is now apparent that the savings to be obtained by using this inspection method will be worth while.

CO-CHAIRMAN MCMASTER.—In concluding our meeting, it might be desirable to make a brief summary of the points which have been brought out in the discussion.

I believe it is self-evident that non-destructive testing is *vital* in many industries. It is vital not only because of the safety factor, but because it has a vital influence on production costs, an influence for which we have no adequate measure.

It seems that the proper use of non-destructive testing can save much in manufacturing cost. Perhaps cost accounting which establishes the costs of non-destructive testing would be an aid in deciding when non-destructive testing would be useful.

It is evident from the examples shown that the choice of proper uses for non-destructive testing may save as much as 100 to 1 in terms of time, labor, and cost.

It appears that there are cases where proper uses of non-destructive testing will eliminate extremely costly destructive tests, and in the long run guarantee a better product.

It seems to be mutually agreed that we should use non-destructive testing at the earliest possible point in the production process, getting the information reliably, and thereby cutting out production costs between that point and the final inspection. This might be one of the most valuable points in lowering our costs.

The phrase "use the right non-destructive test at the right time and place" is a very apt one. I think it has been one of the most constructive points we have made in this discussion.

One of the best ways of getting mass savings in production is to take advantage of mechanized non-destructive testing on parts in motion, to speed production, and thereby lower costs.

It is evident that we need agreement between the consumer and the producer on what constitutes acceptable and rejectable conditions in products being tested non-destructively. The non-destructive test can measure and evaluate the presence, size, shape, and distribution of defects, but it cannot in itself tell whether that particular defect in that particular location is critical or of no consequence in the service applications under consideration. That is a matter of *judgment*, and requires the designer, the stress engineer, the materials man, those who know the service conditions, and others to contribute their best judgment.

Industry-wide cooperation and coordination might be a very helpful thing in lowering over-all costs and making the benefits in improved non-destructive testing developed in one industry available more quickly to other industries.

We have seen examples today of potential ways of saving in our own industries. Mr. Ball's important point that non-destructive testing is a tool for

lowering the cost in the development of new products and new processes is undoubtedly vital. Since development costs are now growing so greatly that it is often a gamble as to whether or not we can recover development costs on any major development, this point is very critical.

I think that a vital question now is: What can Committee E-7 and those interested in non-destructive testing do to serve management best in providing information? In what form can that information be best provided? What is the information we need most? How can we get it to management?

We would welcome your suggestions, your discussions, your comments, anything which might aid us to direct our efforts in Committee E-7—which serves management as well as the non-destructive testing industry—to do a better job in these activities. Suggestions are solicited.

I want to thank all of you who participated in this meeting, and particularly Mr. Lester, who is Chairman of our entire symposium.