GAGES FOR PRODUCTION

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SPEAKER--Mr. Clifford W. Kennedy, Quality Control Engineer, Federal Products Corporation

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Mr. Clifford W. Kennedy, Quality Control Engineer, Federal Products Corporation, was graduated from Worchester Polytechnic Institute in 1917. He then joined the Remington Arms Company (U.M.C. Bridgeport Connecticut Works) as a factory engineer. For over two years he worked on factory layout, equipment, and the methods connected with producing small arms ammunition. He then served the M.S. Wright Company of Worchester, Massachusetts, successively as product design engineer, service manager, and as assistant sales manager. He rejoined the Remington Arms Company before the start of World War II. A few months later he was assigned as chief inspector for the prime contractor at the Army operated Denver Ordnance Plant where he headed the contractor's inspection department. The work included devising, planning, and carrying out essential inspection, quality control, and gaging programs. At the close of World War II, he joined the Federal Products Corporation, makers of gages and precision measuring equipment, as chief inspector and later as field engineer. He is a Fellow of the American Society for Quality Control and the author of two books: "Quality Control Methods" (Prentice-Hall) and "Inspection and Gaging" (Industrial Press). At present he is Quality Control Engineer with the Federal Products Corporation, consulting with manufacturers on problems connected with inspection, gaging, and statistical quality control. He is also Training Supervisor for his company.

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MR. KENNEDY: (After a few preliminary, informal remarks, Mr. Kennedy launched into his technical talk.)

Measurement probably started way back in prehistoric days when some cave dweller back there said, "I want another thing like this." Unfortunately, he didn't get it because it seems to be a law of nature that no two things are alike. In other words, duplication is impossible.

Industrially, we simply attempt to duplicate dimensions or, as we say, we work to as close tolerances as possible. And, of course, here is where precision linear measurement comes in.

I am not sure which came first--industrial progress or measurement, but they are very much tied together. As the ability to measure progressed, industrial progress came with it. Right now, we in our industry are a little ahead of manufacturing. We are able to measure to the millionth of an inch successfully, but manufacturing cannot yet readily hold to such a close tolerance.

Historically, measurement standards have been necessary. The yard, for instance, was at one time the distance between King Henry's nose and the tip of his middle finger stretched at arm's length. The thumbnail, whose Latin word was uncia, was likewise a standard, and from this practice we got the word "inch."

For us in America, probably Eli Whitney made the most important contribution to measurement methods as far as early history is concerned. Our schools have made Eli famous for the cotton gin, but he--not Ford--is really, as you know, more famous for having invented mass production.

In those days the gunsmith made the gun himself--the stock, the barrel, the trigger, the little parts, and so on. Eli said, "Well, if I have one man make stocks, another barrels, another triggers, and another man put them together, I will get more muskets." He did and got them faster.

Then he discovered that these parts didn't fit, so he devised gages. His first attempt was to take a little flat piece of metal and cut a slot in it. He said to his man, "Now, your piece has got to fit this slot." If they did, they went together.

What I am trying to bring out by that is that we still have Eli Whitney's gages, after these many years. Here is one (demonstrating) a

little bit more modern, a little bit changed, but no different from what they used back before 1800. They are still in use in our shops. They have their place--I am not denying that--but they are a symbol for lack of industrial progress. That is the first point that I want to stress.

Any of you who have been or may go to Watervliet Arsenal can see on the wall up there a set of wooden gages. They look like tennis rackets. In the time of the Mexican War those gages were used to measure cannon balls. You might be interested in passing this picture around, and take a glance at what they did back in those days. Watervliet now has those gages in a glass case. Its personnel are not using them. But, nevertheless, at Watervliet and Frankford and some other places the gages are no more modern, because they still have little slabs of steel with holes in them, and they call them gages.

I go into shops across the country, modern in every respect--automatic machinery, the latest in tools, parquet floors, conveyors--everything you can think of. And then I get down to the man on the machine, who is actually making the product, and I look at some of the gages. I see something like that (demonstrating), some of this old stuff. I feel like the chap who is getting into a Cadillac in these days, but he is still putting on goggles, a cap, and duster.

This thing called precision measurement is another part of the background which is growing up. In effect you in the Armed Forces are responsible considerably for the fact that we are demanding more precision today than we used to. Toward the end or at the end of the last war, there was a great deal of magazine publicity about the ability of the chap in the air to pinpoint an oil barrel 30,000 feet below and hit it; they ascribed their success in bombing to the Norden bomb sight. Then the magazines come out with the story that these bomb sights were made in mass production to tolerances of a tenth of a thousandth.

That had its effect on the public, gentlemen. Some years ago, for example, I owned a well-known make of car. It did 50 miles an hour, and it lasted about 50,000 miles. Today you expect a car to be able to do 100 miles an hour at the least and to last at least 100,000 miles. The difference between the two products is precision. In the old days two-thousandths of an inch tolerance was a mark of master craftsmanship. Today two-tenths of a thousandth you can throw a cat through.

In those days we cut out two-thousandths worth of metal and dropped it on the floor. Today we leave it on the parts, fit them together by selective assembly, and let you wear out that extra metal. You get more wear, you get less vibration, and you get less trouble. That is the modern tendency.

Coming back to history again--for more than a century the craftsman would use the equivalent of this steel rule and a pair of calipers somewhat in this fashion (demonstrating), and he could measure repetitively as close as one sixty-fourth of an inch which is about .015".

Then a Frenchman by the name of Vernier in the early 1800's devised a way of subdividing the inch into thousandths, and since then we have had Vernier instruments of which this is one (demonstrating).

About the time of the Mexican War, a Rhode Islander by the name of Brown sailed over to Paris to investigate Vernier's products with the idea of making them in America. He not only came back with the Vernier principle, but he had also seen a screw thread caliper device for measuring. As a result of his effort, we now have the Brown & Sharpe Micrometer (demonstrating).

From this point on I want to describe the progress made in measuring instruments and devices, especially in the last decade, but there are a couple of principles or philosophies I'd like to discuss for a minute or so because they are so important to the successful securing of conformance of product to the specification.

Modern gaging equipment takes into account the important element of timesaving, and here is one small demonstration of what I mean.

A man is making, we will say, pieces like this, multidimensional. They are shooting out of this automatic at the rate of 100, 200, or more a minute. We will admit that he is conscientious, that he takes a piece once in a while and checks it. He wants to be sure that his work is right.

Here he has a micrometer. I am not knocking the micrometer. We make it. But the first thing he does is to check this shoulder here (indicating). Then his second step is to roll this micrometer down to the next shoulder. Then the next step is to roll it down to the third shoulder and get that measurement.

Now, gentlemen, the biggest muscle in the body, so I am told, is the one that runs upward from the back of the knee and, being the biggest muscle, it gets the tiredest. I want you to get the picture of a man leaning against that muscle, measuring, concentrating, looking.

Suppose instead of a 20-dollar mike you supply him with a 30-dollar gage, with which he can measure this piece this rapidly (demonstrating). Anybody can read a clock. Do you get my point? The actual timing on this job, gentlemen, is six seconds against 22 seconds. By that means you can help your job along.

We have another situation in this background. Most of the work that we make is multidimensional. This is a piece here. It has all

of the dimensions. You can see this piece coming out of the machine. Tool after tool worked on this and brought this out, as we say, in one operation. The man has to check on every one of these things.

Well, you can see him here. He will try this one here with a thread gage. He will run over to another one. Then he will go over to a third one. How many pieces is he going to check at a piece rate with that kind of gaging?

So we tried to modernize that. We have the thing down now so that he makes this piece, he puts it in a gage like this, and he reads instantly everything that he needs. That one costs about $500. I don't know what this miscellany of gages does cost.

I was told by a Ford engineer--I am not certain of my figure, but you can get the precise one--that its people are willing to invest $1,500 dollars in equipment if it saves three seconds of time. They think that is good economy.

But anyone who tries to put in modern time and scrap saving gage equipment is going to meet resistance. In the first place, the mechanic who has been using traditional and conventional equipment like this (demonstrating) isn't going to readily change to the new. One stunt is to fiddle around the operator's machine with the new style apparatus, measuring some of the pieces the operator is making. Then we just leave the gage there and walk away. What's more, we apparently forget the gage for several days.

Well, as soon as the chap can get his foreman out of sight and everybody else and maybe the fellow next to him isn't looking, he will commence to fiddle with it. So we go back in about three days, and we pick up the gage and we start to walk off with it.

The fellow will say, "Hey, bud. Where are you going with that gage?" We say, "Well, shucks. You didn't like it the other day. We didn't think you cared for it. We forgot that we had left it with you."

He said, "Bud, I want that gage or one just like it." And, he meant it.

"Well," we said, "Why? What happened here?" He said, "Were you ever driving at night and have your headlights go out suddenly?" He says, "That is the position I am in now when you take this away from me. I can't see where I am going."

Resistance to the new and better isn't confined to the worker level. You find some pretty solid barriers among the foremen, in the engineering

strata and especially among those who sign the requisitions and stand responsible for spending money. The latter, so many times, confuse price with cost.

Here is an example in this hydraulic valve component. (These valves are made for the Air Force and are supposed to withstand pressures something like 10,000 pounds to the square inch in oil.) The operator in a shop making these valves was roughing out these components on an automatic at the rate of about one per minute.

The lad was given a gage like this (demonstrating) which, incidentally, cost the toolroom about $5 to make. He used it to check the size of this hole reamed to .0005" tolerances.

I'm going to pass this plug gage around. You can see where it was dropped and got well nicked up. What you can't see was the time a fellow used it as a hammer to drive in a nail.

The scrap and rejections by inspection from this job ran steadily nearly 20 percent. More to the point, the valves in which these components were eventually assembled showed up as "leakers" on final test to the tune of nearly 40 percent. To make 100 valves and only get a net of 60 is rather poor procurement--what?

So we went to the boss and offered him this gage (demonstrating). "What does it cost?" he asked. We told him, $165. He shook his head. Why should he replace a $5 gage with a new fangled $165 proposition?

However, we went down on the job and loaned them the $165 gage for a long period of time. In that period the scrap and re-operation loss dropped at the rate of $3,800 per year. On top of that, the leaker at final test tapered off from 40 percent to 7 percent. You can see what the $5 gage cost.

All this emphasizes the point that the place to check the conformance of product to specification is at the point of operation. Usually, if you give the operator the proper gaging equipment and set up his operating cycle so he has adequate time to check his output, your quality problems begin to shrink toward the vanishing point.

The next thing in the gaging line is this: If you are not getting the quality of product that you want, it is necessary to do something about it. I don't mean sending out letters and directives; and I don't mean pounding on the desk. I think it was someone in the Air Force who was talking to a pilot and said: "Now, when the paper work in connection with this flight equals the weight of your plane, take off anyway."

What I mean by doing something about it is have somebody responsible; get out on the job, to the operator. For instance, at the Denver Ordnance Plant during the last war, where I was the Chief inspector, there was a shortage of gages. Somebody sent us some glass gages. They were of this general type, but made of glass. They were perfectly good gages and they measured all right; but, if you dropped them on the floor, they weren't any good any more. So we went out on the floor and said: "Fellows, these are all the gages we have. They are perfectly all right, but please be careful with them. Don't drop them."

I went out on the floor the next day and, to my astonishment, I found those fellows out there actually gaging for a change, instead of reaming holes the way they were before. What I want to demonstrate is, we did something about it. It doesn't matter what the higher ups supply the man, if it is something new, something along this line, something different, he gets the idea that the men up above mean that they want conformance and quality, because they don't write a letter and they don't post a bulletin, but they do something about it.

With this much introduction and background, I should now go ahead with what I was invited here for: that is, to describe and discuss linear gaging equipment. I will try to take you through apparatus that is good for a sixty-fourth of an inch to equipment that can discern a millionth of an inch.

The primary industrial measuring tool is the steel rule. You can measure with reasonable accuracy to a sixty-fourth of fifteenthousandths with that. A little depends on the type of piece that you have, that you are trying to measure.

It it is a matter of diameter, the usual thing that he does is get a pair of calipers and check the measurement that way.

Coming up a little modern, we have taken the caliper and we have put an indicator on it; we can measure the diameter of a piece directly and quickly, like that (demonstrating). I know of one concern out west that, several years ago, when the foundry shortage was on, bought a bunch of these and used them in its shops and foundry. The employees of that concern controlled the wall and the web thickness of their castings with the calipers. Previously, they had done it with a steel rule. They control it so well now with an instrument of this nature that they commenced to buy castings by the piece instead of by the pound, and both the foundry and the concern made money, and the deliveries picked up.

Probably the next thing to be talked about is the micrometer. That is a marvelous tool. A recent addition to it is to put an indicator on

it, and also to put on what we call a constant-pressure micrometer. I can have six of you measure a pin with this micrometer and come up with six different readings. One of you may have a hand like a ham and another a hand like a schoolgirl. But with the indicating type of mike with the spring-loaded anvil, one of you has to get the same reading as the other. When you are working down to tenths, that is essential.

You have a measurement like this (indicating) to make. A chap will come in with a Vernier caliper. He will fuss around like this. He usually has to use a glass. I haven't taken as much time as he would take to get that measurement correctly. What I want to point out is this: How much faster, how much more accurate, it is to do that (indicating). The indicating gage measures instantly. You have a gain in time, a gain in effort, and a gain in accuracy, which is essential today.

With the indicating type of instrument we come down to tenths of a thousandth, or to have a tenth, to fifty-millionths. With the air gage we come down to fifty-millionths. In a minute or two I will regale you with millionths.

Back of it all, of course, I couldn't talk about measurements without mentioning the gage block. There (indicating) are five inches in space, which is accurate to about five-millionths. This is our basic measuring tool. With a set of these gages, we can rack these up together like this, pile them up to any length we want, and things of that nature. I bring that up because it is part of a gaging talk.

Along with that, we have come up in the industry in the last few years with what is known as the air gage. I would like to demonstrate it for a second. You are going to see it in the motion picture, but it is better seen in action than over a film.

The other thing I want to bring up is this: I will say dogmatically that when it comes to hole measuring, probably the best solution in the world up to date is the air gage. Here is a little job. This is a piece from a textile machine, but it has a bearing in here that is a little important. According to the plug gage, this is perfectly all right. It goes in the "go" and doesn't go in the "no go." Perhaps I can demonstrate it with this air gage. It is about four-tenths of a thousandth off size. It has taper, and it is out of round. Yet under the conventional method, the old-fashioned method, this piece was perfectly acceptable. No skill required on the air gage.

While I am demonstrating air gages, let me also suggest one other point. Up to this minute I have brought the work to the gage; that costs money. It is much better if the worker is able to bring the gage to his work. Well, we are all set (demonstrating). The work is in the chuck, all held in there. He just brings his plug over it, reads the gage, and there he is.

We will show that in the picture. I did want to give you just a look at that ahead of the picture and fasten in your mind the matter of air gaging.

Now, following along from a sixty-fourth or fifteen-thousandths, to the thousandth, to the tenth, and to the half a tenth, to fifty-millionths, we came next to the electric and electronic, and, incidentally, to the millionth of an inch.

With the electric we introduce one other feature. We can hook an electric gage to the ordinary indicator. The man still has the ability to read his indicator, but on top of that he can see lights flash--red for oversize, green for onsize, and amber for undersize.

The American eye is conditioned to see a light. Having something of this nature hooked up to your machine and going by flashing lights would speed it up tremendously, because you obviate the instrument reading lag.

In creating an electric impulse, you have done another thing. I mean, in order to light that light, we have created an impulse. Now, we can amplify that impulse. We can send it anywhere we want to. We can have it, if it goes red, travel through and stop the machine. You can have it ring a bell. I don't care what you want it to do, you can do it as soon as you have created an impulse. That is the next point I want to bring to your attention.

Then finally, with practically the same idea except that it is electronic instead of electric, we not only have the electric impulse, but because of electronics we can begin to measure in millionths.

This instrument here will take millionths. You can see, I am working backward here. That millionth flashed by so fast, working backward, that I could hardly control it. You will see a lot more of this in the picture.

The other point I wanted to bring up especially to you in front is the effect of temperature. I am just simply going to put my finger on the back of this column, and you down here, at least, can see that needle crawling right along. What the heat of my finger is doing is buckling that piece of this instrument.

We in industry are working to ten-millionths, fifteen-millionths, five-millionths, and things of that nature; and for that an instrumentation of this nature is necessary.

We can also take this impulse again and, as you will see in the picture, we can classify parts by sizes, we can stop machines, we can do things of that nature.

I don't have half an exhibit here; I couldn't strip our shipping department of the necessary gages. But, as we stand in the industry today, we can come up with almost anything that is needed.

We have a picture which takes us from this stage that I have shown you right up through the automatic gaging that is now in vogue. I will discuss that after the picture. We now begin to get into what I call automation and what I guess you call cybernetics. We cut a lot off the first part of the picture because we had a lot of advertising in it.

Thank you.

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