PRODUCTION INSPECTION

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PRODUCTION INSPECTION

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COLONEL GODARD:

Gentlemen, the lecture this morning might well have been on any one of three approaches to the subject of production inspection. We might consider it from the highly specialized angle of inspection in the plant, that is, the actual inspection job, the use of the various tools, gages, and so forth; various types of inspection -- electrical, detail, spot, 100 percent, magnetic -- things of that character. I am sure you would not enjoy that one. Secondly, we might discuss inspection organization policies, that is, the top level organization of inspection, the district level, the policies, how they originate, and how they are handed down. I believe you would find that very dry also. Those of you who are 'Inspection Service' officers might enjoy it. The third approach might be the philosophy or the actual functioning of inspection. As far as I am concerned, I believe that if there is going to be any gold-bearing ore in this lecture, it will lie in the latter broad approach.

I have no statistics, no charts, and no alphabetical combinations to offer to you. You have been hearing about WPB, PRP, CIP, SIPC, and a whole lot of other alphabetical combinations. I have none to offer.

Now having no statistics and charts might well be excusable. <u>If you have no alphabetical combinations, that is an unforgivable sin.</u> As a matter of fact, during the war it was almost treason. You will probably recall that everybody who came to Washington immediately got himself tangled up with either alphabetical designations or some such catch phrase.

Contrary to the general belief, this subject of inspection is not new. It is not even modern. If you go back through the twentieth century, the nineteenth century, or even the eighteenth century, you will find inspection was a recognized problem. As a matter of fact, those of you who are production people will probably agree that the first mass production was premised on inspection. I would like to prove that to you by citing a case that I have in mind.

In 1798 Eli Whitney, who invented the ginning machine, decided to go into the making of guns. The Ordnance Department was trying to acquire forty thousand guns, or muskets as they called them then. Eli Whitney bid on the total contract and got the job.

This was the first time anyone had ever bid on such a tremendous quantity. In almost every instance people who had made muskets for the Army had lost money on them, and in lots of cases they had been put out of business and ruined.

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Now, before Whitney went into this proposition, he had ten muskets made by hand. He was the inventor of the jig and fixture as we know them today. He invested all of his own money in this deal and a lot of money that he borrowed -- what, in those days was a lot of money, today very little. When they were made, he threw the whole ten muskets at his own technicians and told them to mix up the parts and make them interchangeable, so that they could be assembled into a musket that would work. He was able to assemble ten muskets from the mixed parts, that would work. He based his bid, which was the low one, on that particular assumption. That was the beginning of mass production in this country as we know it -- jigs and fixtures and dimensional control by inspection devices. Of course it wasn't as standardized as we think of it today.

I would point out to you that the Army was very much worried over this particular job of Mr. Whitney's. I should like to read you a letter that I found in the "History of Ordnance" for 1799, dealing with this particular subject. This was to the Secretary of War from the then Colonel of Ordnance, who corresponded to our Chief of Ordnance.

"Mr. Whitney having never before engaged in such a business, and not having workmen brought up to the trade, was under the necessity of contriving original tools and modes of executing various parts of the work adapted to the inexperience of his hands, and calculated to obviate the necessity of employing men alone who had been bred to the trade."

This next paragraph is the real one. "The advances the Government had made were heavy, amounting, I think, to $20,000 or more." That shows you how worried the Army was.

The rest of the letter goes on to say that this officer, who, incidentally, must have had a great deal of courage, thought so much of Mr. Whitney that he recommended he be allowed to continue. There was serious consideration being given to taking the job away from Whitney. But he was allowed to continue, and the muskets secured were the best that the Ordnance Department had ever had.

Inspection generally was bad in those days. If it hadn't been that way, maybe General Mad Anthony Wayne, when he went on his expedition the Indians, would not have had to live off the country because the supplies that had been forwarded to him were of such poor quality that the men refused to eat them.

The first contract ever let for a naval vessel carried a specific provision for inspection. "Examination of the hull" it was called -- "Inspection of the ordnance and examination of the hull." The hull evidently meant the whole ship. But the record shows that the first guns were rejected because they failed to meet their fire tests. The letter from Captain Joseph Fox, of the Navy, which was written on the 7th of August, 1797, brings that point out fairly well. I would like to read it.

"Sir, I am directed by the Secretary of War to request that you will make inquiry whether it may be possible to procure at Baltimore by purchase 26 nine pounders and 12 six pounders suitable for the Algerine Frigate. If such guns are procurable you will be pleased to state the price demanded for them. Mr. Hughes having failed in his contract with the Secretary of the Treasury for nine and six pounders for that ship has greatly disappointed the Secretary of War," and so forth.

Evidently they were having inspection troubles in those days too.

As time went along we increased the complexity of armament generally. We had gone from the Indian wars, in which poorly trained troops took part, to the Civil War and down to the Spanish-American War. We got constantly closer tolerances, which required more and more rigid inspection.

During World War I it was fully recognized that, if we were going to produce in mass quantities, we very definitely were going to have better control of the inspection factors than we had. During World War I gages first began to come into their own and supplant the use of manual dexterity. In most cases before the First World War inspection had been a highly skilled operation in which a man, by long years of trial and error, had learned the feel of gages. For instance, one man would be able to tell if a thing was relatively too thin by feeling of it. There it was the sensitiveness of his fingers that did it. But during World War I we began to transfer some of that skill from the fingers to the gage.

The experience of World War I and the lessons we learned made possible the tremendous industrial contribution in World War II. I would like to quote to you one specific example in Ordnance which will show the situation.

A review of articles written for current periodicals dealing with the subject immediately after the First World War indicates that the word "inspection" was practically synonymous with the word "problem." From the record it is certainly obvious that there was definitely a problem in World War I. A quotation from an article in the January-March, 1921, issue of "Army Ordnance" entitled "The Gage Problem in Ordnance Manufacture" sums up this situation as follows:

"It was the experience of the Ordnance Department during the World War that delays in getting into quantity production were very largely due to the impossibility of securing proper inspection gages for controlling the accuracy of manufacture as well as determining the conformity of the manufactured materiel to the specifications governing its inspection for acceptance. This situation arose from the fact that at the outbreak of war there was not in the whole United States of America anything like the number of gage designers, tool makers, or shops equipped to manufacture gages commensurate with the magnitude of the problem in highly accurate and highly interchangeable manufacture required by the munitions program."

There were problems other than interchangeability of manufacture and inspection. As you know, we decided over here to make certain components for our allies. Notably, we took on the manufacture, or tried to take on the manufacture, of most, if not all, the small arms. That program fell flat on its face on the basis of gages purely and simply. I would like to make another quotation. This is from an article in the May-June, 1924, issue of "Army Ordnance" entitled "Gages and National Defense."

"A careful observation had been made of all the rifles in use by the allied forces, which only served to reinforce the general belief in this country that the United States Springfield, Model 1903, was superior to any other rifle in the war. It was the arm to which our small Regular Army and our National Guard had become accustomed and it was quite naturally desired that the emergency army to be raised should be armed with the same weapon. Lack of gages caused the decision to use another rifle."

From this it can be seen that because of gages, or, rather, a lack of gages, the U. S. Army was required to adopt the British Enfield rifle even though the U.S. M 1903 was considered by our small arms experts to be the superior weapon.

In the long armistice between World War I and World War II we had very little chance to use these mass production lessons. The Army was small and its procurement was infinitesimal from the mass production point of view. Of course, the lessons that had been learned were forgotten. We went from the unskilled or semi-skilled machine type of inspection back to the highly skilled, 100 per cent inspection.

You can readily see why that was so when I tell you that, for example, in the Air Force a mass production article was considered to be thirteen airplanes. Obviously you can't tool up for mass production for thirteen airplanes. It is going to be a hand-to-hand proposition, and the number of inspectors you will require is relatively small. That type of requirement, of course, calls for highly skilled men, capable of handling any specifications or prints. It obviated immediately the training and use of semi-skilled inspectors.

Then, again, manufacturers during peacetime have high reputations and they must maintain high standards. Contrast that with World War II, in which we had such astronomical quantities of munitions. I think the most outrageous comparison, if I may use that word, to show the difference in quantity is the AAF. You will forgive me if I refer to the AAF. I know that story a little better than any other story. In 1933 the aircraft procurement program of the Army Air Forces was zero. In 1944, eleven years later, it was one hundred thousand. Now, obviously, when you get changes like that, from zero to one hundred thousand, in a period of eleven years, any system that you have in the zero days is going to fall by the wayside in the hundred-thousand days.

I do not have the figures with me for the Navy or for Army Ordnance, but I feel sure that they must be the same. If they are not I would be very surprised.

Then, too, in wartime you face a much more important problem, the problem of conversion and subcontracting. For example, the Servel Corporation, Evansville, Indiana, was established originally for making gas refrigerators. We converted those people to making wings for the P-47 airplane and all the components. Hudson and Chrysler, who were making autos were converted from automotive parts to the manufacture of the B-26 airplane and to tanks and guns. The Frigidaire Corporation was converted to manufacturing machine guns for Ordnance. I think the most amazing example of them all was the Mills Brothers in Chicago, who were making Cola Cola machines and slot machines--"one armed bandits"--and who wound up making droppable wing tanks for the P-38. That is really a conversion as far as I am concerned. Burroughs, who had been making an adding machine, which is a fairly simple machine, went to the most complicated machine in method of production, I believe, that came out of the war--the bomb sight.

Obviously, we were getting complications in manufacture that those people had never gotten used to. New and extremely close tolerances were forced on them. It was impossible for the small inspection staffs of the Army and Navy and Air Forces to meet the burdens imposed by this high volume of conversion and subcontracting.

Some drastic measures had to be adopted to meet this wartime inspection problem. There were three basic solutions that could be applied: A, you could expand the inspection force; B, you could reduce the amount of inspection; and, C, you could improve the techniques. But each of these solutions simply served to magnify the problem that was faced in inspection.

Let us consider them in detail. If you increase the force, where are you going to get the highly skilled inspectors? You are in competition with the manufacturers for those people. The manufacturers normally will pay them more than you in the Army will pay them. Then when the manufacturer gets them, if they are smart they will go on the production line, where they can make more money than they can make in the manufacturer's inspection division. By all normal reasoning your chance of increasing your force with really skilled people is practically nil.

Then, too, you must remember the inferior status of government inspectors. During the war they had a low pay scale, I had hundreds of inspectors working for me getting twenty-five hundred a year. Those inspectors, if they went to work for the contractor, producing goods, could get four and five thousand a year for making the parts instead of inspecting them.

Then, too, top side in the Army--I don't know whether this is true in the Navy, but I certainly know it is true in the Army--does not appreciate what is required of a good inspector. I think the best proof of that is the fact that inspectors, instead of being graded as "Professional," are graded as "Clerical, Administrative, Fiscal." You might have something that cost

five hundred thousand dollars and on the final inspection line there would be a "Clerical, Administrative, Fiscal" employee deciding whether it was acceptable or not. B-29 airplanes for example.

The services were forced to rely on the leavings, the left-overs from the manufacturers' personnel requirements program. I can say this to you, in all fairnessto the people that we had. We had more than our fair share of soap box orators, letter writers to Congress, and marginal screw-balls, whom contractors would not hire. That type of people did us no good at all. Don't misunderstand me. There were hundreds and hundreds of fine, sincere, hardworking men and women in the inspection force. But as a general rule we got a very poor class of people. We couldn't expect anything else on the pay we were going to give them.

Now, using this type of personnel involves breaking the jobs down to the point where no judgment is required, where there are no decisions to be made, and where the person will function purely mechanically. Even with that breakdown you have got to have some training. We tried to install a good training program, but there were few teachers available. Men who were capable of teaching were going out and getting twice the money doing the job that they would get for teaching it.

We had many, many inspectors put to work in the services with as little as two weeks training. I can recall one instance when I was walking down the line and I saw a man with a mallet hammering a go-and-no-go-gage through a piece of metal. I asked him what he was doing. He said, "I never saw such a place in my life. They can't make a thing that will fit. I have to hammer everything through."

That man was working on a go-or-no-go gage proposition. I am not going to explain in detail what that is. But one end of this gage was supposed to go through the metal and the other end wasn't, if the item was to pass inspection. He was making them go through with a mallet.

We come to the second solution, which was to reduce the amount of inspection. To do that you would establish inspection stations at key points in the line. Such a system must utilize spot inspection or sample inspection. Sample dips at the whim of the individual inspector. From that system came what is now called statistical control of inspection. I haven't time to go into that. Suffice it to say that I believe it is the future of inspection.

The third is improved techniques. X-rays of castings, fluoroscopes, magnetic inspection, Magnaflux. Magnaflux in particular. The Magnaflux inspection simple is this: You take two contact points, shoot a current through them, and induce an electrical magnetic field. You set your item to be inspected in between these two points. When you have induced your field, you pour a fluid over the item to be examined. The fluid contains iron filing The iron filings obviously will spread across the field, and wherever you may have a crack in the part or a fault, the filings will show a line.

That was a fairly skilled operation, because it requires a great deal of judgment as to the determination of whether or not you have a crack at the end of a shaft or whether you have an inclusion, something ground in during the grinding operation. That was one thing that gave us trouble all through -- the Magnaflux operation.

Then we had the optical comparators. That is an operation where you take a piece and show it on a screen with a paper pattern behind it. You enlarge it sixty to one. You have at least a magnification of sixty to one. When you put your part on, it shows on the paper in the rear. You get a perfect indication, a sixty times magnification, as to whether you have a fit or not.

We finally come to the use of gages that do the thinking. In a recent seminar, someone said; "We put the skill in the gages and took it out of the inspectors." Some of those gages were amazing. I am not going into detail, but I will go over two or three of them briefly.

A micrometer is a gage that has been used ever since we have had machine shops. It is adjusted with a little roller. You can read off tenths, hundredths, and thousandths of an inch. Someone designed a visual micrometer, so that as you turned your gage, you got a reading up in here on a little dial. (Indicating on paper) That allowed the reading to be done without the man having to squint at the gage, and took some of the pressure off the process.

Then we got the electronic gage. That is one that can be operated by persons who have never seen a machine shop. They can learn to operate it in five minutes. You simply pass a piece through this gage and instantaneously you see a light flash on. (Indicating) You have limit lights and you can instantly read for green "O.K. Within the limits" or for red read "Oversize" and for amber "Undersize." You can pass two hundred pieces a minute through an inspection device of that kind and eliminate almost all of the human element.

One of the most amazing developments of recent years is the anemometer system, with which we gage parts for dimensional tolerances. That is a fairly involved principle, and it pertains to the pressure of air against the part to be gaged. The pressure is recorded on an anemometer, which is something like a thermometer. You can read the pressure up to 25 millionths of an inch on the enlarged, expanded reading dial. (Indicating) You can see the slightest variation by the increase or decrease in the pressure of the air. As I say, it is fairly involved.

The last one is one that was designed primarily for handling by blind inspectors. This is a gage that indicates by sound. You put the part between two contact points. If it is too small, it will not complete the circuit and therefore no sound is emitted. Acceptable parts register a low tone. Parts above the high limit register a definitely high tone. Blind or inexperienced inspectors can use that gage as efficiently as one with one hundred per cent vision.

Such were some of the developments in the gage field. I think that probably the Federal Products Corporation, of Providence, were the leaders in that specialized field. That is no plug for them. They are members of the Army Ordnance Association and members of the Navy Ordnance Association. They will give the services anything they want any time they want it. I think it is only fair to mention people like that when they do the things they do, and they do it with very little hope of practical return. The Ordnance Department told me the number of gages they required during the war. When I expressed amazement, they cited specific examples. They said that for a complete round of 105-millimeter ammunition, there were, at the peak of production 173 facilities making the various component parts; that is, cartridge case, shell, primer, fuzes, metal containers, etc. A conservative estimate of the number of types and sizes of gages in use currently at each of these facilities is fifty gages. In other words, approximately 8,650 different types and sizes of gages were in constant use at 173 facilities in order that proper functioning and interchangeable components could be delivered to the loading plant. It is estimated that at least four sets of gages were in use at each of these 173 facilities producing components of 105-milimeter ammunition. Thus it can be seen that for this one complete round of ammunition, 34,600 gages were required in order to carry out the proper inspection.

I can see by the clock that my time is running out which reminds me of the lecturer who was invited to the University of Pennsylvania. He found that he had left his watch at home; so he fixed his eye on the clock on the back wall of the lecture theater. Unfortunately, in the back of the room there was a curtain; and, while he was laboring a point and wandering up and down, someone for some reason closed the curtain. He didn't even realize for several minutes that it was closed. He had forgotten about the clock.

Along about half an hour later he suddenly looked at the clock to get his cue and was flabbergasted to see that the thing was missing. So he started to explain that he hadn't noticed the clock being covered up and he just didn't know what time it was. But then a voice from the audience spoke up and said, "That is all right. You can still see the calender, I hope."

Now, I would like, if I may, to make a comparison between the prewar and the wartime inspectors. The prewar inspectors were highly skilled. They could make on-the-spot decisions based on judgment. The World War II inspectors were unskilled labor. Usually they were trained in one process only. They were incapable of making decisions.

In that one fact lay the greatest source of trouble in inspection during the war. The production personnel, both military and civilian, expected that these wartime personnel would be able to make the same decisions based on judgment that they had been accustomed to getting from highly trained inspectors in peacetime. It was impossible, of course, and for the reasons I have just stated. These people used gages rather than minds to do the job. A piece either fitted or didn't fit as far as they

were concerned. Occasionally somebody stepped overboard because of the prodding of the production men and would accept a piece that was outside the tolerances.

The strangest thing was that every time that happened and a piece bounced, the poor inspector could never find the production man who sold him the bill of goods. He always took the blame. You can readily see that if this happened a few times, the entire inspection department of a plant made up its collective mind "This is it. It either meets this specification and passes inspection or it does not" and anything else is going to be rejected.

That brought many, many foolish decisions. I recall the case of a B-26 chrome-plated parachute hook. We had to inspect the plating by projecting the hook through a salt spray and all chrome plating was supposed to stand up under 250 hours of this spray without breaking down. One day these parachute hooks broke down under 94 or 95 hours, and the inspector rejected a thousand of them.

Joe Eskridge, the Hudson Corporation production manager, came into the problem at that time and said, "What are you going to do?" The inspector said, "Knock down these parts." Joe said, "But we can't get anybody to make them any better. We can't even get anybody else to take the order." Then he asked, "Do you know what these are going to be used for? These are hooks to hang parachutes on."

Now, those hooks never should have been plated in the first place. This inspector was perfectly within his rights. He was a green man and knew nothing about what they were for. His instructions were that they should pass the 250-hour test. It was not his fault. It was the fault of the design engineer who put that plating requirement into the contract specifications originally. These inspectors didn't have the ability to use judgment. They knew the inspection sheet. That is all they did know.

Wartime conditions, that is, unskilled labor, made a new definition of the role of inspection necessary. Inspection is the "Supreme Court" of procurement. Let us carry the analogy just a little bit further. If you consider engineering as representing the Congress, legislating the law, and production as the executive, putting the law into effect, inspection would be functioning as the Supreme Court, interpreting the law. If you think of it that way, I think you will see the point I am driving at.

Added to the pressure on government inspection from the production services and on down, there was the numbers racket. Inspection was under production on the organization chart. Even though industry had said for years that inspection must report to engineering or to the general plant manager and under no circumstances should report to production, in 1944, I believe it was -- correct me if I am wrong -- ASF put inspection under the Production Division. That is like letting the prosecuting attorney sit as the jury to decide whether a person is guilty or not after he has put him through the third degree.

Many other things enter into this picture. As I mentioned a moment ago, you have tolerances. You have design engineering requirements that are absolutely unnecessary. Someone said last spring on our lecture platform that the British and the Russians didn't waste time finishing the outside of a gun barrel. It doesn't improve the firing qualities one iota. I have seen people busily polishing a B-29 because somebody didn't like to see any marks on it.

I have seen sheets for the side of an airplane rejected because they didn't butt up. Let us say just to illustrate, that the tolerance was an eighth or a sixteenth. I have seen places where the sheets were a little wider apart than that eighth or sixteenth inch tolerance; and some damn fool inspector -- there is no other word for it -- wanted them to take that whole sheet off and put another one on. They fill up the crack with cement anyway so it doesn't make any difference if it is a little wider. I believe the engineer was wrong when he set that tolerance. But the print required it and our wartime inspector was doing his job, in his opinion, if he rejected it. The fault lay, not with the inspector but with the design engineer who set up the tolerance in the first place.

There is one solution to the problem, the relationship of production to inspection. You can install quality control which will make the manufacturer fully responsible through his design engineer. The design engineer will have to accept his responsibility for tolerances that are too strict, in one of two ways: Either by forcing him to scrap huge quantities of materials because they don't meet the inspection setup, or by forcing him to allow a huge fraction of defective material to be used. Now, both of those are very salutary, because they both expose great weaknesses in his work. They make him determine the maximum allowable defective factor of the product.

I would like to summarize for you now.

After World War I we abandoned the experience we had acquired. We went back to the peacetime, one hundred per cent inspection, caused by small procurement. We developed again our small, highly skilled force of trained inspectors. To say the least, it was unrealistic.

As far as that is concerned, we are going right back into the same situation now. It is the shortage of personnel. Everybody tells the same story on this platform. They haven't enough people. We are going back very fast. It looks as though we are going to lose the lessons of World War II, just as we lost those of World War I.

You might very well say to me, "It is all very well for you to criticize, but what have you got to offer as a possible solution?" It is a fair question and I will take it. This is a suggestion only. It may not even be a solution. It is a horseback opinion from an inspection man with a very long term of training. Let's look at the picture as a whole.

First, let us take the wartime inspection organizations. What are the problems they faced? (a) They faced high quantities requiring inspection. (b) They faced low skills of the labor force. (c) They faced inexperienced manufacturers.

What are the solutions? We can develop these statistical control inspection methods. We can put more skill than ever before into the gages. We can make real quality control a part of all contracts and enforce it.

In the early days of the move for Irish freedom, about in the eighties, the Ancient Order of Hibernians in Boston held a mass meeting, at which an Irish spell binder exhorted the brethren of the Hibernians at great length to come through with a lot of money for the cause of Irish freedom. After a most moving speech of about thirty minutes he was through. The master of ceremonies got up and looked over the audience and said, "Would there be any man in the audience who would like to ask any questions?" One man said, "I would like to know what has happened to all the money we have given for the last fifty years." The master of ceremonies on the platform said, "Sergeant at arms, do your duty." The sergeant at arms promptly dragged the man out of the hall. When he returned, the master of ceremonies on the platform looked around and said, "Would there be any other questions?" Are there any questions?

(No questions.)

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