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PRODUCTION ENGINEERING

19 January 1956

CONTENTS

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PRODUCTION ENGINEERING

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GENERAL CALHOUN: Gentlemen: So far in our studies we have been through Requirements and the consideration of the structure of our industry up to the consideration of how our needed end items are produced.

Our speaker today is Mr. George L. Downs, Plant Manager of the modern Great Arrow Plant of Sylvania Electric Products in Buffalo. As you know, his long experience in electronics, engineering, and production properly fits him to discuss with us today the subject of Production Engineering.

When he was here last year he characterized the production engineer as the man who translates the dream of the scientist and the development man into the reality of military hardware.

It is a pleasure to welcome back to the College and to present Mr. Downs.

MR. DOWNS: General Calhoun, Faculty, and Students of the Industrial College: I feel like I do have something to say to you, and yet, by the rules of speaking, I am not supposed to say anything for about five minutes. I suppose you are aware of that.

I was talking to Captain Wright on the way over, and riding past the Lincoln Memorial reminded me of the time that I was very interested to read that a historian was certain that Lincoln had not delivered the Gettysburg Address to the people at Gettysburg, that on that particular occasion he was speaking for the record. The historian knew this was so, because it was such a short speech and Lincoln had not warmed himself or the audience up before he started.

So I have to take a moment, I am told by all the rules, for us to get a little bit acquainted and for you to become accustomed to the peculiarities and the sound of my voice, my delivery, et cetera.

I very much admire preachers. You know they make their living by speaking, and whenever I see a good one in public--not in church, but in public--I know he is going to ease into his talk very well.

Up in Buffalo a little bit back the Sales Managers decided they had to inspire people a little bit, so they got Dr. Peale up from New York City. He does very well. I admire him. I sat there and was entranced, and at the same time intrigued, with the process. He said, "I work with a lot of psychologists in my church. I enjoy it. We do a lot of good for a lot of people. I will tell you privately, though," said he, "they are a mighty queer lot." Everybody got up and sort of looked around. He said, "There was a convention down in New York City not long ago of psychiatrists." It was in that big hotel opposite Penn Station--I don't remember the name of it. He said, "A lot of pigeons that are normally well balanced and rational pigeons flying around Penn Station got somewhat deranged by the presence of so much emotional instability in all the people at this psychiatric convention, and one of them went across the street and flew into the ball room of this hotel where the convention was being held." He said, "Do you know, it was two days before one psychiatrist would admit to another that he saw a pigeon flying around the ball room.

I don't seem to get my stories in gracefully like that. I have to drag them in by the tails. I do want to tell you one that I have had a lot of fun with in the last few weeks. This is about logic. You may have use for this sometime. It seems that there was a biology professor who, in lecturing to the class, had a frog. He held the frog in one hand and held the other hand out, and said, "Jump." The frog jumped to the other hand. Then the professor removed the legs from the frog and put it back in his hand. He held out both his hands and commanded the frog to jump. The frog didn't move. He said to the class, 'Now, class, you have observed that, when one removes the legs from a frog, he becomes quite deaf.'

Well, I am going to take it for granted now that you can hear me, and I do want to talk about Production Engineering. I think the first production engineer on record for the military was Eli Whitney. I think you know the story about Mr. Whitney astounding the military authorities of his day by taking in ten army rifles, disassembling those rifles, mixing all the parts up on the table, and reassembling the ten rifles. This, at that time, was unheard of. I am sure you are aware of the implications that that brought to the military of the day.

Prior to that time, every spare part had to be hand tailored. Prior to that time every rifle was a hand-fit job. Here now, at one stroke, we have broadened the base of our supply. We have arranged it so that parts can be made in various plants and fed to one point for assembly. We have arranged it so that spare parts may be carried in the field so that any broken part may be replaced at any time from spares. We have arranged it so that, if we have one damaged piece, the good parts can be cannibalized off that part and the parts may be saved so as to make a lesser quantity of good assemblies.

That, essentially, is the work of a production engineer. Now, I have to examine this thing carefully so that you can understand what I am trying to get at. Let's just review the kinds of engineering there are as applied to military equipment.

First of all there is research. Research engineering in general is aimed at coming up with an idea of proving theoretically that a certain thing can be done, or investigating the possibilities and developing a theoretical concept. Yes, we think you can do certain things.

Here is a report of our reasons why. Here is the mathematics. The output of research engineering is frequently on paper, a report of some kind.

The second type of engineering is what I call development engineering. The development engineer has the assignment usually of producing a working model of a piece of hardware or equipment that will actually perform the task, that will do what the research man said could be done, or he has the problem of devising an equipment that will fill a specific military need somewhere. Now, this man is part scientist, yet part production engineer, and exactly what he is depends, of course, on his education and background.

But if I have anything important to say to you gentlemen, it is this. The output of a development engineer is not necessarily a production design. Now, if I sound vehement about this, it is only because I am. I have been on the receiving end of so many, or have seen so many, mistakes made by people who ought to know better, and I am criticizing the military at this point, people who ought to know better, in assuming that because they had a working model and some drawings they had a production design. It looks like a production design. The drawings are made to the standard military format. It uses all the required number of components. The model works. What is the matter with it? Why isn't it a production design? This is what I would be asked, you see.

The reason it is not a production design is that it has not been production engineered. The job of the production engineer is to make certain that it is a producible, reliable, manufacturable piece of equipment.

Now, in just a moment we will put on the blackboard the steps necessary to do this and the time required, approximately, to do it. In electronics this problem is widely recognized now. I don't like people that get up and read things to you, but I hope you will bear with me just a minute. Here I have an address by Mr. J. M. Burgess--it is a copy of the thing--Director of Electronics, Office of the Assistant Secretary of Defense, 5 October 1955, at the working conference on the reliability and maintenance of electronic equipment at the Aberdeen Proving Ground.

I quote: "It is now universally recognized that the reliability of military electronics is generally so low as to constitute a serious threat to the operational readiness of many of our major weapon systems. Furthermore, this low reliability results in a maintenance effort of staggering proportions in both manpower and money."

He quotes a project in the Rand Report in 1952:

"This analysis has established that it is costing the Air Force about two dollars per year to maintain every dollar's worth of airborne electronic equipment. Therefore, during the life of the equipment, somewhere between 8 and 10 times its original cost is being spent on maintenance."

This is not peculiar to the electronics industry, but the electronics industry at the moment is the one that is turning out the least reliable equipment. Fundamentally, electronic equipment is less reliable than mechanical equipment because of the vacuum tube and other aspects; but it does not have to be as bad as it is.

This is not a new problem. I have a book I brought along out of my book shelf at home, called "Production Engineer" by Earl Buckingham, who is Professor of Mechanical Engineering at

MIT. He quotes here from something written in one of your journals back in 1933. Army Ordnance was the publication. A fellow named J. D. Peterson wrote it. At this point he is talking about what happens when you try to put a gun into production. Probably it is a mess. He says: We got models. The models functioned well in themselves; their components readily interchanged from one to the other; but upon measuring these components it was found that in many particulars they did not agree with the drawings nor among themselves. Frequently the drawings carried tolerances difficult to procure under mass-production methods.

He talks about all the travail that they had there at the factory. I commend this article to you, gentlemen; I really do. He said: What happened when we got all done was this: All our work resulted in the adoption of tenable tolerances with limits adjusted to secure interchangeability. I might add beyond that point they were striving for reliability in the field.

We will now come back to our design engineer. He turns out a design, and this design works. We have a working model. He is pretty proud of it. It is a functional design. This can be electronics, it can be anything. He has not thought about what is going to happen to that design when somebody puts the part in an airplane and carries it over the Hump at 60 thousand feet. He has not thought about what is going to happen to it when it lands on a beach head and somebody kicks it. He has not thought about what is going to happen to it when somebody takes it over a hard road, or any road at all. He has not thought about what is going to happen to it when it is operated at 120 degrees. He has not thought about what is going to happen to it when it is operated at 30 below zero. If it is a piece of equipment that requires speed, he has not thought about what is going to happen when the velocity drops 20 percent below what it is supposed to be, or rises 20 percent above what it is supposed to be, or the frequency varies, or many other things.

If it is a piece of aircraft equipment, would he consider the vibration we are encountering in today's jet planes and missiles which go at a good-size market price? If it is to be a piece of ship-borne equipment, does he know, when a particular set goes off on a battle ship, the shock it gets as the ship moves in the water? Some of these shocks are terrific.

The answer is no. I want to tell you gentlemen the military is not the only group that has this trouble with designers. I brought along a prop here. This gadget is the eye that goes on the dash board of a Lincoln to look ahead and see the beam of the other fellow's headlight and lower your own. It is called a headlight dimmer. We make them. To talk about economics for a minute--this thing sells for 45 bucks. In here is a tube that costs six dollars. We would like nothing better than to get rid of that photo multiplier that is the heart of this gadget. We are working with people on all kinds of devices. They say, "Yes, we think we can help you." They develop a gadget, see. So we ask them some of these questions I have been asking. They say, "Well, gee, we have worked along this line." They will produce a thing. If, every time you go out and get in your car, you calibrate this, make an adjustment, it will work fine for about a week. They will make a gadget that will be O.K. provided you don't drive in Arizona, where it gets hot, see.

Well, I guess you realize that at least I think there is a lot more to a manufacturing design than there is to a functional design.

Now I will give you all heart failure. We will talk a little bit about time. This will effect those of you who are in procurement.

(Writes on blackboard.)

These are years. I will back off a little further. Let us take a piece of equipment, some reasonably complex device or other. This theoretical piece has never been made before--not this thing. We want it, and we are going to get a design engineer to do it. After that we want to follow up with production of some hardware. So, the first thing our designer does is his work on paper, the bread-board of the thing, to prove up this movement and that circuit, to check the various devices accurately and get them all coupled together so that they work and he can build a model of our device. I will call this the first or the bread-board stage. That will take about 6 or 8 months.

The next thing he will do is build a model. This will start back while his bread-board stage is still under way. Probably in a month or two later that model will undergo some rather extensive tests. He will make some changes. At the end of the year--you might say already we spent our year and we spent our R&D money--we have here a functional design. And here, brethern, is where the mistake is made.

Let's see--my lecture assignment was that we begin with an approved design. You can see why I am suspicious of an approved design. This is what we have now, a functional design. Let's say you gave that to us in our factory. What would happen? Generally we get a model GFE. You say, "Here it is. It works, boys. Now, take it away."

The first thing we will do is check the drawings and the circuitry and the scale, shove a pencil around, make a few layouts, and see how it looks to us. Are they asking for tolerances that can't be met? Those of you who are familiar with radar will know what I am talking about. This equipment is the microwave guided coaxial fittings and so forth used to pipe the engine. Those of you who have worked with it can figure out that everything there has to be held to tens of thousandths of an inch, because the frequencies are so high. You may also know a lot of it is brazed together. The temperatures run in the order of well over cherry red, so it is up over 1000 F.

Being a practical guy--at least I hope I am--I know when you heat something it expands, and when you cool it it contracts. When you run it through heat cycles like that it does not always come back to where you started from. I was given once some drawings that required me to braze an assembly and hold it within a couple of thousandths in overall length. It was 40 inches long. All you have to do is look up the temperature expansion of bronze, which is what this thing is going to be, to assume that the temperature will be the temperature of silver solder, which may move over one-half inch and won't come back where it was supposed to be.

Well, I check the drawings and look to see if we have a manufacturable process, and we will build a model. We will spend

Neither does the GFE. Honest to goodness, now, one thing that is a mystery to me is how in the world so many GFE models that are built to a certain specification get out in the field without meeting that specification. I don't know; I honestly don't. I don't have the answer, either. But anyway, it does not. So we test the model. That is about a 3-month run, generally. If anybody talks to you about life-testing something, it will run three months. Most of the military tests that you will have of end-to-end testing, including the life test, in general will run close to two months. Quite a few are around-the-clock operations. You have to allow a little time for breakdown, time for making changes as you go. You have to write a report. It has to be reviewed before you are through with the test. In our thinking we allow three months, with a little time for making changes.

That has brought us up to the end of a second year, at which time I would now say we have a manufacturable design, or a manufacturing design. Now, if you want to talk about an approved design, we have one. I agree with you.

What do we do now in the factory? We get an engineering release. That means that the engineering department officially says to the factory, "Here are the prints, specs, and model." That release is generally made to the planning or production control group within the factory. There is immediately a meeting between the manufacturing superintendent and the head of industrial engineering, who is responsible for time-study movements, equipment tooling and purchase. He has to go out and buy all the stuff we don't make in the factory. The planning supervisor sits down with them and they separate this whole project. It may take quite a while. They decide what they are going to make and what they are going to buy. This determination has to be made. We don't buy all the parts the way they are on the prints. We buy some. Others are bound with secondary operations to be performed in the plant.

All of this information has been recorded on the bill of material. The purchasing department will determine the quantities involved in each instance for the job and the schedule. We all agree on that. Requisitions are released to the purchasing department for the items that have to be bought and the plan for the work that has to be done at the plant, and the project is finally launched.

That will take two weeks to a month, depending on the size of the project. I will call that planning activity. We will give that a month. Now, the purchasing department has immediately made orders for the outside tools and parts that are going to be made on the outside. It will begin to line up vendors. In ordinary times it will get competitive quotes and try to establish sources for these parts. I have to talk with reference to electronics, but ordinarily, assuming that we have been cognizant of what was coming, we have gotten in and released some of our long-term tooling items ahead, like die castings, which are pretty much a six-month item anywhere, we believe that in about four months we can have tools made, die castings, and samples available.

So, let me expand this scale a little bit. We called up to here another year. In about four months we have samples. Now, these are samples of parts off production tools. We don't authorize the men to go ahead and make 5 thousand, 10 thousand, or any quantity. We want some samples. They come in. The purchasing department submits the samples to our engineering department. The engineering department puts them in the laboratory. Somebody checks them out to the print, to see if the components are in order, and runs them through the various environmental tests. If you build good equipment, you have good parts.

In electronics you have a circuit that has to operate through extremes of temperatures, or the parts have to operate through extremes of temperatures. Somebody says, "This is a jam part. Here it is. Take it." That doesn't mean anything. We put it in the cold box. We want to see it work at 30 below. We shake it. We want to see it stand vibration. We put it into 30 days' humidity, or the salt spray, or the hot box, to see it do whatever it is going to have to do.

There is no way to build good equipment without good parts. We call that operation parts approval. That takes a month to two months, overlapping some of this. So we will say it is a month after we have samples in that we have parts approval. We go back to our supplier and say. O.K., with changes. Proceed. It will be another two months before we have material in that we can get going on.

We call that production material. Let's see; if I add this up, that is seven months after we have our production release from scratch. We have production material in, ready to do something with it.

Meanwhile, of course, the rest of the plant has not by any means been idle. The factory engineering group, the industrial engineering group, has been laying out the assembly area, has been setting up special tools where required, has been designing and devising assembly fixtures, has been writing process sheets to indicate everything that has to be done inside the plant, providing equipment, gauges, and fixtures. Generally these are scheduled to be in readiness at this time.

So we will write down here, production facilities, these having been started several months prior to this time. Now, we have the production facilities, all this proved-out material. So we are surely ready to go now, aren't we? No.

The next thing we do is this. We can begin this back up there a little. We generally overlap a little. I am just making this agonizing, I guess. What we have to do now is get our production foreman, who is going to run this job, and a few of us key people together. This is the assembly stage. This is where we are going to make or break this thing, or prove it out by engineering.

We start at the beginning of each operation and do the operation. If there is anything wrong, we catch it right there. We assemble one of them all the way down the line to the end, following instructions exactly, making any last-minute changes that are necessary. That unit then has to be tested, has to be shown to engineering. We ask, "Is it all right, engineering?" If engineering is not standing right over the operation.

If it is approved by everybody, it goes right up into the place where the job is going to be carried out, and becomes a model. Now we are ready to go? No.

The next thing we do is bring in all our people that are going to do this job, and they run off a representative quantity--25, 50, or 100--something like that, using this set-up that we have established.

Then we quit. Everybody goes home. There are big conferences, to prove up what was wrong, to see if everything is all right. Perhaps there are some last-minute corrections, little difficulties, things that don't fit, things that seem to fall apart, things that drop on the floor.

Now, we are ready to go, at the end of our prove-up run. We can call the people back and put them to work, put the material on the line with reasonable assurance that it will go out into the field and we won't have customer complaints.

Let me just finish this. I said we would build a model and have a prove-up operation. Let's say that would take us probably a month. So we say that eight months after the production release of a really approved design, we get under way.

Now, this may seem far fetched to you--the detail I have gone into--but it is not. It has been learned by bitter experience by those masters of mass production, the automobile people, that things like this have got to be done; and this is substantially the kind of process that goes on anywhere, any place, where the people running the company have their own money invested and know that if the thing does not stick in the field they are going to go out and map it up at their own cost. So, from an absolute point of view of equipment reliability, this is it. When you meet these specs, boom!

Now, back to my prop, the Lincoln dimmer. This is a story about us, me. Last year we had a six-volt dimmer. This year, of course, it has changed over to twelve volts. The engineer changed his design to a 12-volt design. We omitted the pilot run, because the changes were so minor--no problem. Well, I wound up with a pretty sad mess on my hands. What we found was this: After we got the tubes that we buy for this little seeing eye--they cost six dollars apiece--half of them would not work in the equipment. There was incompatibility between the requirements of the control unit and the output of this tube. How did this come about? It came about because, in re-specifying the tube, one engineer said to another engineer, "I think this is how it is going to be." The other engineer took his word and redesigned on that basis. When the specifications were resolved and the tube manufactured, they were not like that. We bought tubes to specifications. We can't return them to the manufacturer, because he has fulfilled his obligation. We can't use them, because the equipment won't work. I now have 18,300 dollars' worth of tubes.

Why did we do that? We did it because it was just a simple little thing and we thought it would be all right. There is another company that manufactures that same thing. They did a similar thing about two years ago. They let a transformer get out in the field. They had to replace it. I was talking to the sales manager of that company this Monday, and he told me that corporation dropped over a million dollars replacing that little transformer in the field in their little headlight dimmer.

If the automobile companies can make mistakes like that, careful as they are--and they appreciate the implications of everything I have said here--then you can see what kind of trouble it is easy to get into if you don't appreciate these implications. If I sound like I am carrying a message, it is only because I am.

Now, I have five minutes here before questions. There are some ways to shorten this. Naturally, in wartime and so on, nobody is going to sit still for three years from the time somebody needs a radar to the time he gets it. By then the war is over.

What can you do? Well, first of all, if you have engineers who are genuinely production engineers, they can do your design work and you can substantially combine the first two phases right away and cut a year off the thing--maybe not a year--about 8, 9, or

10 months. These fellows are doing more work now. They are starting out from scratch and packaging as they go. That is not too satisfactory a way to do it. The only trouble there is the absolute scarcity of engineers who actually know what production engineering is. I am not blowing anybody's horn now. That is just a fact. Read the New York Times Section 3 sometime, and look at the want ads if you think there is not a scarcity of engineers in general.

That is step one, as far as collapsing the schedule is concerned. Now, if you want to risk something, we can start taking some chances. It is going to cost you some money. The thing we can do is this: The engineering model, when it gets all built, has got to be type tested. That's three months' work. If you want to, you can release your design to the factory when only the operational part of that type test is done. That will save you 2 or 3 months. It does mean that more change notices will be written after the release of the equipment.

The third and last way borders on insanity. I have been through it, and maybe it is really necessary sometimes. This is it: The last way is to sit your designer down and have him start work like so (writing on the blackboard). This is absolutely the fastest you can do it. As soon as he determines he is going to use something, or thinks he is, you go out and buy it. Every time this fellow picks out a part, somebody orders five thousand. As he goes along, he will build a model. He is building that model along here (demonstrating). Every time he runs into two parts that don't fit, he makes a change. Somebody reworks five thousand of them. Every time he decides he can't use a part, somebody throws away five thousand.

When he gets down to the point where his model is pretty well along, somebody is going to start building the first of five thousand production units, and will follow just as close behind him as they can possibly do so.

Obviously, you can see what is going to happen. It means you don't have a manufacturing set-up at all, but just a glorified model shop, and it means the stuff is extremely costly when done in this way. But I have seen projects in World War II produced from nothing to something on a boat in 8 to 9 months by this fashion. On very small and not too complicated projects, I have seen things done this way very recently, on semi-R&D jobs, in six months from the requirement to the time that the thing was gotten out.

It can be done, but it is not what you call production engineering.

Now, my time is up. I was going to get into automation and a few of these special areas. Maybe we can do that during the question period.

Thank you very much.

CAPTAIN WRIGHT: Mr. Downs is ready for your questions, gentlemen.

QUESTION: Mr. Downs, during your talk, it sounded like quote a bit of your GFE turned out to be GFU. The main thing I wondered about is, in your production stage who takes care of the maintenance and overhaul aspects That includes the ease of maintaining, and the ease of overhauling.

MR. DOWNS: I really don't know. I guess the usual procedure is that the designer designs with that in mind, inasmuch as the thing is to be put together anyway. If it does not work it has to be taken apart and fixed. The production engineer, in whatever military group, is cognizant of this. Your procurement officer has certain things in mind, where he has been listening to his services. Those ideas are frequently requirements of this particular department. The way spare parts and field-service manuals are prepared is strictly an after-the-fact situation, after the design has been made and is in production, usually, or near production, with model available and prints available. A spare-parts provisioning team will show up from the concerned military group and will sit down with the engineers of the facility concerned, and they will go down the line and look at the thing and what it does, and visualize their problems, and say, "Do we want to utilize this as an assembly, or do we want to have the pieces? What do you think?" They will debate a while. Finally they will say, "We are going to put in assemblies and stock spares." If I can use a Navy term, they will say they will put parts in the equipment spares, and so on. That is the provision made in a provisioning meeting. Instantly after the meeting, when there is not enough procurement time, they want spares concurrent with the equipment, and always after that it generally becomes incumbent on the contractor to prepare a service manual and a spare-parts list, complete instructions for adjusting, repairing, and servicing the equipment.

Does that answer it?

STUDENT: In other words, it just happens. Nobody preplanned it?

MR. DOWNS: I would hate to say it quite that brutally, but I don't think that in the fundamental, functional design of this thing too much thought is generally given to the service of it. I would go so far as to say I think it is a secondary consideration.

QUESTION: I am sure we would all like to hear your comments on automation, which we did not have time for in the earlier period. At least, I would like to know what you have in that fish bowl there.

MR. DOWNS: Of course I was hoping somebody would ask. Automation is defined really fancy as having the elements of feed back and control and brains that are going to replace humans and so on. I am one who can't see anything different that we are doing now from what we have been doing since 1814, except just proceeding step by step on the pathway of making the machine the servant of man. That is all there is to it.

The reason I brought this along is that this is one of the first automatically produced radios. This particular radio was actually made on a machine which is referred to in our company as automatic. They have been using the term "automatic" for a long time, referring to the automatic screw machine, and so on. These are 50 years old.

I am going to leave this radio here. You fellows can look at it and listen to it. It is an ordinary production unit right off the line. The only thing I did different was to have the boys put it in a box that you can see through. What happens is the wiring is etched on a copper laminated plastic board. Holes have been punched. Most of the components have been put on by machine. Some of the deep seated and more complicated ones were put in by hand. It was hand assembled in the cabinet. Rapid intake is made by one stroke of the die, which cuts out copper sheets in the form of a rectangular spiral, and it adheres on the basis of firm setting plastic to the plastic back. That is all there is to that.

This is as good an example of the product of automation as I could get my hands on. I thought maybe you would like to have it. Automation in general really is mechanization, if you want to use those terms. That is all it is. The hope that you are going to eliminate the human being in the aspect of feed-back or control I say is nothing new. The things done are not awfully startling, either. It has been a slow process of getting automatic controls of that sort, over a period of years. The plastic industries and the oil refineries have been a marvel of this type of thing for a long time.

I mean, let's not get excited.

QUESTION: I was a little surprised at your statement about the servicing not being given more consideration. Maybe I have been reading the wrong propaganda, but I understood that, particularly in electronics, a great deal of attention was being paid to whether you built assemblies to be exchanged as assemblies or parts to be thrown away or sent back to the factory for repair or an effort to repair individual parts.

That has great impact throughout the whole service, right down to the recruiting people and their training, as to whether you train them to be electronics men or train them to push an assembly into a box.

I would like to hear more about that end of it, if you please.

MR. DOWNS: I have to agree with you. Maybe I am wrong. Maybe a better answer would be that I really don't know. With respect to the design aspects of equipment, I do agree--not in electronics particularly. As you say, the package circuit plug in the throw-away type of package circuit is coming. Perhaps if I rephrase my answer in this fashion it will be better: From the production engineering and factory standpoint, we never see these considerations at all. That is a more satisfactory and perhaps a more accurate answer all right.

QUESTION: If you make the final production model of the equipment, aren't you going to get into that business some place? Doesn't someone in your organization say, You can't make it that way. Joe Blow out in the field has to get in there and fix this piece.?

MR. DOWNS: No; those considerations have to be handled at the time the original specifications are put on paper. I think this is where we are missing it, perhaps. In my capacity I don't work generally directly with the project engineers in the various military groups. Once the design is under way I see very little consideration for that aspect, until the provisioning meeting, and of course, like anything else, I see mistakes made in provisioning along these lines of provisioning. I see parts that people in the field absolutely never could put together and make work.

By the way, I saw a project not long ago that was designed along the lines you said, a throw-away plug in units. Now, a year or two years after that design was all approved and everything, do you know what is happening? They are provisioning the parts of these things. I don't know why. I really don't. Somebody must have figured it would save money somewhere.

I would hate to be the fellow in the field who opened one of those. They are sealed in a little can. It looks like an overgrown tube.

QUESTION: Mr. Downs, I am one of your ship customers. I wonder if you can tell us about someone else getting into production and using your plans, and also the problems of your getting into production again and using your own plans after a lapse of time.

MR. DOWNS: All of these things, of course, are a matter of degree. It is a truism that no set of tools can ever be moved from one press shop to another press shop and be any good. They don't work. They are terrible. They have to be worked on. I guess it is human resistance to something that is not your baby.

There is a little of that when you move a design from one place to another. We would like to think that, if our drawings were put into another plant, with a reasonable amount of model building and a preliminary prove-up that these would prove satisfactory. It would not be entirely so, we do find.

It has been my personal experience many times that changes made in the equipment are not actually reflected in the drawing. This, of course, is the bugaboo--when things are in production and the drawings do not actually reflect what the parts are or the processes that are required. When you take those prints and put them into another organization, that organization has to resolve the problems that were solved when the original processes were established and the prints were never changed. They stumble on it themselves. They may solve it another way. You may unintentially find an interchangeable problem in the field between the products of two manufacturers. It varies. I have to say it is spotty, transferring one design from one manufacturer to another. It depends entirely on the adequacy of the design in the first place--the production design, the detail design, the careful, methodical, painstaking follow-up on each required specification change. O.K.?

QUESTION: How about your own company reproducing?

MR. DOWNS: Oh, that depends on the time lapse. A year or two doesn't make much difference. There are people around who remember what they did, and the stuff goes right through. In five years or so, maybe with a reasonable amount or organizational turnover, it would not be much different than having somebody else's new design.

QUESTION: One of our problems is engineering changes, as it is your problem. In the services we intend to do this at the time the development engineer says the engineering change is necessary. How do you match this in industry when you are dealing in a profit-making kind of system? Do you set up your engineering changes on a block with an approved quantity, or is there a time element?

MR. DOWNS: That depends entirely on the urgency of the situation. Let me say that I am 99 percent engaged in military work myself, but, on a commercial product, if you have a situation that requires a change you make it then and there or no more equipment will be assembled, or no more will be shipped. It is pretty obvious that change is going to be made right then if it is possible to do so.

STUDENT: It is a very large change, though, that is affecting the workability of the equipment?

MR. DOWNS: Right.

STUDENT: Many of our changes in the military are not that kind?

MR. DOWNS: Well, I can't really quote a rule of factors being weighed. We put it in at the point that seems the most reasonable. There's always the cost of obsolescence and the likelihood of liability in service being incurred to consider. The special weight we can give to the replacement materials or parts to make the change is the factor that has to be considered.

In general what we try to do is not to make any change that we don't have to make. In automobiles and radios, here's a model. You make this model this year, and next year you have a new model. If that is what you mean, any change made once a model is in production is extremely mandatory and required by either a lack of supply of a part or by unforeseen variations--that's a non-offensive term--in the product. O. K.?

STUDENT: Yes.

QUESTION: Sir, would you comment on the ability to transfer production designs in the electronics field between countries? I don't mean between the English and metric systems, but between the United States and Canada on the one hand and between Britain and North America on the other hand. In other words, could our electronics industry produce a British production design.

MR. DOWNS: I have had absolutely no experience with that at all. I do know that with offshore procurement a lot of European people are producing American designs, with some hand-holding by Americans, and apparently it is being done all right. I do know a Sylvania-designed aircraft communications equipment was built in England right after the war, with a great deal of difficulty. I know it is being done, the same as you do. I have not been closely enough associated with it to know what the real problems are. I have never heard an awful lot of complaints about it. I would guess it is slow; kind of like starting a new business from scratch. More things come unglued than you would expect, and it requires a great deal of attention for several years, I would expect, to make a satisfactory transfer.

QUESTION: In your outline I presume that you are operating on a fixed-price contract, a procurement contract. My question is, if that is so, how do you handle the cost of this engineering work that you were describing?

MR. DOWNS: Your question, I presume, is prompted from the belief that that engineering work costs more than what it saves. The answer is, we don't believe it does.

STUDENT: No, sir. Mine is a purely academic question. It is not loaded at all.

MR. DOWNS: We put it in the bid.

STUDENT: In your fixed-price bid you include it? I am trying to get at the fact that you brought out that you really don't know what you are going to get; so the extent of engineering work involved must be a difficult thing.

MR. DOWNS: It is customary when a bid is let--I don't have the right word--somebody will have to fill me in.

STUDENTS: Advertised.

MR. DOWNS: When it is advertised there will be a briefing meeting. All those concerned in it will come to the briefing meeting. At the briefing meeting there is generally a model or one set of degraded prints, which for the most part are not readable, and in mind. There are lots of preferred items. Any time a fellow wants to use an item that is not on the preferred list, he has to justify it to the agency involved. The answer is not really changing the specifications at all, but trying to live by the ones we have.

So I guess the direct answer to your question is this: There is a way. It is not written. It is not enforced. Maybe it can't be enforced. I don't know.

QUESTION: Mr. Downs, I would like to volunteer some information on this maintenance engineering problem. When the pre-production samples, the originally designed samples, worked out by the laboratory maintenance personnel of the laboratory, come in, I think, from the Army's point of view, for the purpose of checking the parts, reasonable maintenance can be given to them. This is the reason you can usually provide them to a small group before they go to the final maintenance people. This group does get into the arrangements of pre-production and engineering models.

MR. DOWNS: That is something I don't know. I wonder if somebody else can add to that. This is a subject I hate to see dropped.

STUDENT: In the Air Force in the war we had a 658 part.

The 600 part at that time had to check against the maintenance changeability and ease of change.

STUDENT: It has got a devil lot of attention in the fire equipment in Ordnance. The research people themselves are charged with thing. That is where the automatic tester is roped into the gizmo that has to sit in the airplane. I think that is why we have come to this plug-in circuit. I think one of the reasons was that in overhauling this thing--it cost 500 dollars a unit--it was an expensive thing to throw away. We did discover that, by using additional tools, they could get back into the bidding without having to clean it all up. For a few bucks we can overhaul these things.

QUESTION: I would like to ask at just what stage of this development engineering you decide what inspections are necessary by the company.

MR. DOWNS: For parts or for the completed equipment?

STUDENT: For the completed equipment.

MR. DOWNS: Every equipment is supposed to meet the specifications on which it is bought or sold. Compliance with these specifications is demonstrated by the original type tests. They are called environmental tests. It continues to be demonstrated throughout enough tests that we feel that any unit that you pick out will satisfactorily pass all the environmental tests any time you get ready to test it.

Beyond that, in electronics, generally we have tests on the equipment of a mechanical nature to prove that the wiring is right, with continuity point to point. This is generally done automatically. If there is any large volume, it is a full responsibility of the operational testers to take it though its complete range, make it do all the things it is called upon to do, to be sure it does go right for all time. These operational tests are recorded and are available to the military agency concerned, along with the equipment.

Have I answered your question?

QUESTION: In the electronics field, do you find that the military--all three services--has a tendency to over-design, or to provide more expensive equipment to do the same job that your civilian customers request?

MR. DOWNS: Well, I do believe that in general military equipment is more rugged and sturdier than civilian equipment for the same purpose. I also believe it must be so, for obvious reasons. I have not found in my personal experience any case where people were asking for gold plating where they did not need it, or did not think they needed it. So I guess my answer, sir, would be no.

CAPTAIN WRIGHT: Mr. Downs, on behalf of the College, I would like to thank you for a very interesting talk and discussion this morning.

MR. DOWNS: I am happy to be here.

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