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PRODUCTION ENGINEERING

30 January 1951

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Publication No. L51-93

INDUSTRIAL COLLEGE OF THE ARMED FORCES

Washington, D. C.

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Mr. Paul P. Stock, Chief Industrial Engineer, York Corporation, is a native of Pennsylvania. He was graduated from an industrial high school in 1925; finished machinist apprenticeship; and was graduated from Temple University, class of 1929, with a degree in Mechanical Engineering. He joined the York Corporation in 1930 and held the positions of toolmaker, maintenance mechanic, supervisor; methods engineer, and methods supervisor. He is presently employed as Chief Industrial Engineer.

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CAPTAIN MARCY: As you heard yesterday from Colonel Cave, one of the objectives of the Production Course is to take some of the mystery out of the subject of production. This morning, Colonel Barnes, in his thumbnail sketch of what you should learn from the Production Course, practically resolves it, so that there is no mystery left.

However, in the event some of you are still somewhat mystified, we are very fortunate in having with us this morning, Mr. Paul Stock, Chief Industrial Engineer of the York Corporation, who will attempt further to demystify this subject of production.

It is with great pleasure that I welcome Mr. Stock back to the college and introduce him to this class. Mr. Stock.

MR. STOCK: Good morning, gentlemen. This subject, "Production Engineering," is not mystifying at all. Really, it is very simple. Break it down into the simplest possible forms; then it becomes easy. The same technique would be used in eating an elephant. We eat him a bite at a time--even if we like elephant.

As you came into the auditorium, each of you received a copy of this "passout." Should you be unable to see the visual aids distinctly, you can follow the discussion by referring to the booklet. (Booklet was not reproduced.)

At the York Corporation, we call this subject "industrial engineering." It can be called "production engineering." It can be called "methods engineering" or "process engineering." In some plants it is under the jurisdiction of the master mechanic. It goes by a number of different titles. It can be used whether one or a hundred items are going to be made. Either way, it still pays to go through the analysis sheets and the production sheets in order to come out with a correct estimate at the end of the job. If a correct estimate is made, production can proceed without too many headaches.

First of all, I want to say a word or two about our plants at York, so that you will get some idea of how these sheets can be used on one piece of work, a thousand pieces, or a million--on small work, such as thermostats; on large work, such as tanks. It really doesn't make any difference.

(Charts used during this lecture were not reproduced.)

This aerial photograph shows our two York plants. We have almost a million square feet of space in our plant at Grantley and almost a million in the one at York. The York plant is in reality a jobbing shop. Our highest production at this plant is about five of any particular type of machine a day. The highest production at Grantley is 60 complete air-conditioning units an hour, or one every minute. The production engineering in both plants is done by the same system. The estimating is done by the use of analysis sheets. Naturally the amount of tooling and type of supervision are different and more time is spent on plant layout for the higher production.

At York we try to handle our industrial relations from a human relations angle, and the following formulas are used in our work. The basic needs and desires of people are: security, opportunity, recognition, and inclusion. If we give workmen all these benefits, we don't have too much trouble with them. The formula for group relations is: Understanding modified by tolerance leads to agreement; and responsibility modified by coordination plus incentive leads to cooperative action. Thus formulas are used in all our dealings with the workmen on working conditions and incentive pay.

The following three charts are pictures of the York products in production. They give you an idea of the scope of our products as to size and production. Some are produced one at a time and some on continuous production lines. I do not want to spend too much time on this but I did want to show you that the system works on all types of work. We can now get down to the basic points of production engineering.

In order to make an estimate and to get into production on any item, regardless of whether it happens to be a complete tank or just a little thermostat, there are five basic things that the production engineer must know. There is no order of importance; he must know them all.

The first one in the list is drawings. Naturally, we must have them. Second, we must have the bills of material. In ordnance work, I believe that is called a "list of parts;" it is still a bill of material. Third, the specifications must be known, especially on ordnance or government work of any kind. The Government has some real tricky specifications on its work. Fourth, it is essential to know the yearly production. And what is more important than the yearly production is the required "rate of production." The rate of production means the delivery of five a day, or ten a day, or ten a week, or ten a month. Regardless of what the yearly production is, this is the production on whic the shop is set up--the rate of production. That is the most important item so far as the plant layout and production engineering is concerned.

In the last year we produced approximately 175,000 one-room air conditioners. If that figure is divided by 12 it will show a monthly production rate of approximately 14,600. But since this is a seasonal product we have to produce these air conditioners in eight months. This means a production rate of approximately 22,000 per month. This is why the rate of production is the important item. Yearly production is fine; but all that the yearly production tells is how many items are going to be turned out in a year's time.

The production engineer must know the limiting factors pertaining to the job he is to estimate and put into production. If he can build an entirely new building and equip it with all new machine tools, he will estimate the job one way. If he has to fit the job into existing machine tools, existing buildings, and just buy the minimum amount of machine tools and the jigs and fixtures, he will estimate it another way. Those are just some of the limiting factors that come in before he makes up his analysis sheet.

This chart is called a "manufacturing analysis." It is just what it says. We take each piece and analyze it. We have to figure out how we are going to attack the job. On this particular analysis the first operation is broach.

You will also notice here the locating points. This is very important on any type of work--I will explain why a little later. On all operations the production engineer gives the locating points, the machine on which he is going to do the job, the operation and department numbers, the speed (RPM) and feed he anticipates using, tools, fixtures, type and size of gauges, the select time, and an allowed time to perform the operation. The select time is the actual raw time that it takes a man to do a job. That does not mean he can wipe his hands, take a "chaw" of tobacco, steal a smoke, go to the toilet, or anything else, this is the actual raw time. This must be modified when figuring up a load sheet. We will come to that a little bit later.

You may think the difference between .367 select time and .72 allowed time is considerable on the first operation. This is mainly due to the incentive plan in operation at York. We use a modified Halsey 50-50 system where the workman is paid for one-half the time he saves and the other one-half reverts to the Company. The incentive time plus time for personal reasons and miscellaneous time are added to the select time in order to give the workman a chance to earn some incentive pay before he becomes entirely proficient on the job. We believe this increases production quicker on new jobs. However, we guarantee the man his hourly rate at all times.

The manufacturing sheet also lists the material specifications, size, drawing numbers, date of issue, and space for possible revisions. Just the same as on the drawings, there are some revisions.

To you gentlemen that might seem like a lot of work; but really it isn't. A man can do that very quickly. When he is through with the manufacturing sheet, he can pass it right on to the purchasing agent. We can send the drawings and analysis sheets out to a dozen different tool manufacturers to design and build the fixtures. We can get prices from as many people as we want to send the analysis sheets to. They do not have to come into the plant and take up our time and their time--and time is of the essence, right now especially. We can simply send analysis sheets out to them. They know just exactly how we are going to do the job. They know the machine we have to do it on. Here is the locating point (indicating). This means we are going to locate it (they don't care why) at point "X". They know we are going to broach that piece on a Cincinnati broach. In other words, we could build that fixture in our plant and send it on to another plant and the possibility of its working well would be rather high.

The same way with the drill and the chamfer. We tell the production engineer that we want a fixture for it; that we are going to do the job on an upright drill press.

When we have our job completely analyzed per piece, remember one piece at a time, we have to make an assembly. So, we have an assembly analysis sheet, and on this sheet we actually put the pieces together on paper. We give the machine number (this happens to be a conveyor) and the name of the tools. Incidentally, there is no capital equipment listed on the assembly analysis sheet. We list our tools and gauges, if there are any, and our select time and allowed time. Space is also provided for necessary or possible revisions.

We then have to make a machine-load chart. This is really one of the very important jobs. You will notice we build the machine-load chart before we made a summary of any of the capital or projected tools. It is from the machine-load chart that the number of machines and fixtures can be determined. Perhaps two or three of the same kind might be needed. Four or five of various kinds might be needed. This happens to be a machine-load chart on a part of an air conditioner that we made. But the principle holds good on anything.

We list the types of machines and now know what they are. If we are fitting a job into existing equipment, we naturally know them. If we are not fitting the job into existing equipment, we have made an analysis sheet and we know the type of machine needed.

The machine efficiency percentage on the machine-load chart is one of the most important items. That is a rather illusive thing to get hold of. All plants calculate it just a little bit differently. When calculating a machine-load chart, the select time in the body of the chart has to be used because that is the base time it takes to do a job. But, we know perfectly well that the workman is not going to come into the plant at, say, seven o'clock in the morning and work continually until 12 o'clock. He just is not going to do it. He is going to wash his hands, take a "chaw" of tobacco, or go to the toilet. The machine is going to break down. There is no question about that. The calculated risk has to be built into the machine-load chart. There are going to be errors and rejects regardless of how good the efforts are. I do not think there is anything produced that doesn't have some rejects. So rejects have to be built into the load chart.

On this particular chart we see total efficient capacity in double shift, at 80 hours per week. You will notice the efficiency time is 64 hours on one machine. We say that 64 hours operation is all we can get out of that machine, even though we have an 80-hour week. That probably happens to be a machine on which the rejects are rather high. Maybe it is an intricate job that goes over it. But the calculated risks must be brought in. If we do not bring them in, we come up to the end of the month and find instead of producing 1,000 pieces, lo and behold, we are producing only 800. The expediters and the manager of the company will come down to the production man and say to him, "Look, this select time says you can produce 1,000 pieces. Where are they?" The select time might show that 1,000 of them can be produced, but there is the efficiency angle to take into consideration. That is very important. You would be surprised how many people in industry do not figure that in. They just assume these pieces are going to roll off the machine all day long and that they will come out at the end of the month with a high production figure. But, gentlemen, it doesn't work out that way.

In our company we put out quite a bit of subcontract work. As one of my jobs, I generally have to okay the subcontractor as to whether he can do the job or not. It is always one of my basic questions to ask him to let me see his load chart. Although 99.9 percent of the subcontractors do not have a load chart, I ask them to let me see it, anyway. I am not, after all, interested in how many pieces he gets off a machine in a day. I am interested in how many pieces my company is going to get by the end of the month. I do not care how fast he does them so long as we meet our quota.

I can very soon make a quick calculation. For instance, if the subcontractor has to do the job on one machine and he has 80 hours of work, select time, he is not going to be able to produce the necessary pieces in the required time. Accordingly, I am not going to get full production from him. It is just a little stock question I ask them all. Other good questions to ask are, What is your maximum efficiency? Do you have a load chart with your maximum efficiency calculated in it? You would be surprised how many plants do not have it.

Don't forget setups; they are important. (The "SU" means setups.) That is the calculated amount of time it is going to take to set up the machines. When the figures at the bottom total more than the figures at the top, then another piece of equipment is required. It is just as simple as that.

Work can be scheduled from a machine-load chart. The only time trouble is encountered is when the schedule calls for more work than the machine can produce or when a major breakdown occurs. On assembly it is a question of manpower, space, and assembly fixtures.

If a new plant is to be entirely equipped, the number of machines can be obtained from the load chart. If, on the other hand, we are going to fit machinery into an old plant and just buy a few items, we find that out from the machine-load chart.

In industry we have two different kinds of money, both of them good, I hope. One of them is project expense. Project expenses are those expenses that are necessary to produce the particular job being estimated and include fixtures, processing hooks and racks, purchased part tools, and dies, and can be returned to the prime contractor.

This expense is handled in one of two ways. Project expenses may be paid for outright or prorated over the number of pieces produced.

General expenses are those items that are generally covered in overhead and are not a part of a contract. Items generally put in this space are rearrangement of existing machine tools, cleaning out equipment used on the job previously produced in the area you are going to use, factory development, perishable tools to start the job, and general items such as wrenches, hammers, gloves, and so on.

The next chart is the capital cost analysis and covers the capital equipment in the same manner as the project cost analysis covers the tools, jigs, dies, and fixtures. On this chart, in addition to the name and source of supply, is listed the delivery time, installation time, and in addition to the unit cost the installation cost which

naturally is part of the capital cost. There is a common fallacy among management and prime contractors that the time a machine-tool builder requires is the time to get into production but they forget that the machine may have to be shipped halfway across the country and then must still be installed and tried out.

If it is brought out as an item, anybody accepts it. If it is covered up in the hole, nobody accepts it. The delivery and installation time will determine how soon production can start. This is the best estimate at the time the sheet was made up. That is about all that can be said during the present state of affairs.

The next chart is the cost analysis summary. From this sheet we can tell the projected and capital cost of equipment necessary for each piece in the unit and very often it gives an indication of whether a piece should be redesigned or purchased.

I have heard it said quite often that this method takes much too long. I will admit a lot of time is spent in making up the analysis sheets. But time or money cannot be saved until there is some to save. If we do not know what the job consists of, we can very easily bid too high and not get the job or bid too low and lose money on the job. Time is saved if the job is awarded, not in days but weeks and even months. A very fine example of this happened to us. During World War II we bid on and were awarded a contract for the manufacture of 75-mm. tank gun mounts. It took us 8 months to get into production and then we discovered we had bid many thousands of dollars too low on the tool and fixture cost. There was no lack of desire on our part to get into production, but the fact is that we made no analysis and did not order the necessary equipment on time. Our production rate on these mounts was 200 per month and we had the contract 11 months before we met our monthly production. You can imagine the pressure that was on our department and company during this period.

As a contrast to this, we later bid on and were awarded a contract to furnish 25,000 rockets per month. Analysis sheets were made on this estimate. We started into production on this contract within 12 weeks and were producing our schedule of 25,000 per month in 16 weeks. Why? Because we knew exactly what was necessary and within the first week all tools and equipment were on order. There are many other advantages; for instance, the customers may think the costs are too high and we save time by having all the details available to talk about the job. Again with analysis sheets we can contact many vendors of equipment and get the best price and delivery on the first contact instead of having them come in to see us and then go over the job as many times as there are potential vendors.

Since all the information on the piece is available on the analysis sheet, any purchasing agent can get bids from several bidders at the same time. If the piece of equipment has to be engineered, the vendor can come into the plant with all the information on the first trip. This certainly saves many weeks of time.

The next chart pertains to plant layout and flow process. You will not find anything on it in your "passout" but it is nevertheless a part of the production engineer's job. This is a layout to show how we are going to produce the pieces expressed in time. A flow-process chart must be made to show where the job goes from one operation to another, and it must be made regardless of whether there is a new plant or an old one. This shows chronologically the piece flow from one place to another, or from one part to another.

In this particular plant we gauge everything at the machine. Each machine has its own gauges. On any subcontracting work or any ordnance work that we get, we make positively sure wherever possible that the piece is right on one machine before it goes to the next. There is many an hour lost on a machine when the job is not done right on the previous operation. For example, a man produces his part exactly right but it was spoiled in the operation before. Therefore, the piece is no good. Time has just been lost. That is all calculated in the load chart. Now, if we work on the system that each machine produces its part right or it does not get passed on, we have a smaller percentage of error allowance on the load chart. If we do not do that, then we must allow for it in the efficiency percentage. After all, the company is paid only for the number of good pieces it puts out. I don't think I have to dwell too long on that. I would be very happy to answer any questions on this subject in the discussion period if you care to ask them.

The next chart is an incentive curve. Last December we were asked to repair some tank hulls. I believe they were 40-ton tanks. I do not know the name of them, but they were rather big hulls and were of riveted construction being changed to welded construction. Some of them were battle-damaged, all had mud on them and a few were in very bad shape as they were shot up pretty badly. Our job was to repair them and weld them where they had been previously riveted. We estimated the time for repairing those tanks, using an MTM standard, that is, "methods time measurement." Formerly, most of our standards were set with stop watches. This job, however, was calculated by using the MTM method. We operated the job on our analysis sheets. The job was started on the eighteenth of December and this curve (indicating) shows the time spent in relation to the estimate. By the eight of January the group started to meet our estimated time and was earning an incentive pay. By the eight of January the time (man-hours) per tank hull was down to here (indicating 65).

This shows you what incentives will do. (Referring further to chart.) It shows we got the job on the eighteenth of December. On the eight of January we were actually working on incentives. I say again this was due to the fact that we had our analysis sheets and anticipated what had to be done before we actually started. The job was started on the eighteenth of December and we spent 86 man-hours on the first hull but due to our incentive plan the time came down steadily until we were producing the hulls in 65 man-hours. We could have expected the time to reduce from 86 man-hours to about 72 or 74 man-hours under normal working conditions. When you offer a workman more take-home pay for more work produced, he will generally work harder to get it, provided the time expected is fair.

I have stated before that the estimate and incentive standards for repairing these tank hulls were calculated by the MTM method. MTM is exactly what the words imply. It is the measurement of a method expressed in time and was developed by Maynard, Stegemerten, and Schwab of Methods Engineering Council of Pittsburgh and is rapidly becoming very well known in industry. Formerly most standards were set by the use of a stop watch--timing the workman while he was performing the operation. With MTM an analysis is made of the job and each move, turn, reach, grasp, or stoop has a definite time value and the time is set according to the method used. If the method is changed, the time is changed. There has been a manual written on this subject by the three men previously mentioned and it should be in your library. It is my understanding that government factories are restricted from using stop watches. By this method workers can calculate the time required to perform an operation even on maintenance work. However, they must be trained in the technique.

Now the job has been estimated. We believe that is the biggest and most important part of any job--getting it estimated accurately. There are certain other points in this connection that I would like you to notice. Once the job is let, we have decided on a supplier, and we say, "Okay, Joe, you've got the job; go to work," all that Joe, the production engineer, has to do is the seven articles listed on page 3 of the folder: (1) He has to order all the tools and equipment from the process sheets, (2) erect the building, (3) install the capital equipment, (4) try out the tooling, (5) develop the assembly and test, (6) make a trial run of the plant producing the product at the estimated rate of production and within unit cost. Those are two things the manufacturer has to do: He has to meet the cost because he cannot afford to go broke; and he has to meet the required production or else quite a few people will be coming in and asking why. And finally, to complete the list, (7) transfer

responsibility over to supervision. We tell him, "Okay, Joe the job's yours. I know it will work out according to the estimate because we have done it."

I put a paragraph on the bottom of page 3 of the folders about the common fallacy of thinking that we can produce a job without estimating it properly and expect to get into full production. We will, for instance, estimate the fixtures. We will know all about them. By hitting the high spots an estimate will be obtained on a big job in a day or two, but what is in the job will not be known.

As an example of the use of analysis sheets, recently we were requested to bid on producing gun barrels. As most of you gentlemen know, this entails deep hole drilling, boring, broaching, and honing. This work is certainly not in our line and we have no experience on it. I believe we were requested to bid because we have quite a large plant and are located in the Susquehanna Valley which has a good percentage of skilled mechanics. (Incidentally, we would like to have more.) Since this job was in production, I requested routing sheets or analysis sheets from the contacting personnel and was informed that they were not available. But the gentleman still wanted the estimate within 10 days. Withou the use of analysis sheets this job will consume at least 1,000 hours of a very good industrial or production engineer, while it would take only at 150 to 200 hours if the sheets were available, even though we are entirely inexperienced on this work. When you consider that there are only about 25,000 to 30,000 men in the country capable of making a complete analysis of a job of this size, that is a gross waste of manpower.

On this job we will send someone to an arsenal to observe the job in production; then he will come back home and spend the 1,000 hours estimating the job, unless we can get routing sheets from the arsenal, then we can estimate the job in about 150 to 200 hours.

We are not interested in the arsenal's time per operation, as this can be calculated; however, we are interested in the techniques.

I am not implying that all requests for bids on government work shall be accompanied by process sheets. That would be Utopia and physically impossible. However, on jobs that are in production it would certainly save many hours of time and effort.

Thank you, gentlemen.

COLONEL SEAWARD: Gentlemen, Mr. Stock is now ready to entertain your questions. But first of all I think there is one point he wants to clear up.

MR. STOCK: I would like to make one correction in the booklet you have received. On page 3, cross out the word "Product Engineer" and put in its place "Production Engineer."

COMMENT: If I understood you correctly, method time measurement is computed time. It is estimated beforehand. I was thinking maybe the time could be computed more accurately than it could be measured.

MR. STOCK: I am sorry if I left the impression that MTM is more accurate than the stop watch. The standard unit of MTM is known as an M. T. U. and represents .0006 minutes. All the time values for MTM were derived from thousands of time studies and motion-picture studies. The value of MTM is the fact that standards are set very much faster and the fact that the method must be studied first and false moves eliminated. Also the fact that skill and effort are all computed on the average man when using MTM, while with a stop watch the individual studying the job estimates these factors. I can give you a fine example of the comparative accuracies between the stop watch and MTM. I told you in my talk this morning that we had calculated the time on the repairing of tank hulls. Because of a union grievance we actually time-studied the entire tank-hull job after we were in production and there was only 1.25 percent difference between the two methods. The advantage of using MTM was the fact that it was calculated before the job was started and we had to wait until the job was in production before we could time-study it.

COLONEL SEAWARD: Does anyone care to pursue this particular question any further before we proceed?

COMMENT: Just with regard to time-motion studies, that, it seems, is one of the grievances the unions have had against standing over a man with a stop watch.

MR. STOCK: You are correct in your assumptions. It is my understanding that most of the national unions have accepted the MTM standards. I have been told that the Garment Maker's Unions, headed by Mr. Dubinsky, have accepted it and are planning to use it in their studies. Unions do not like the idea of their men being studied with a stop watch for many reasons, two of which are: first, the psychological effect of having someone standing in back of a man watching him while he is working; second, the elimination of so-called false moves and leveling a man's skill and effort. In time-study work these factors must be leveled inasmuch as all time values are set on the theoretical average man and we all know there are very few average men. Most of us are either above or below average. With MTM these conditions do not exist.

QUESTION: Mr. Stock, I am sure you are aware of the project that the Government is working on for a Federal cataloging program. If and when suitable and effective catalogs are available for government work, what effect will that have on your company?

MR. STOCK: I personally do not know too much about that project. That would certainly be a gigantic job. However, it can be done and it should save industry many hours of the production engineer's time.

QUESTION: I would like, if I may, to ask one question on this projected cost analysis sheet. You have listed there, for instance, Ingersoll Rand. I take it, from what you said, that the tool might be returned to Ingersoll-Rand after the job is finished. Is that right?

MR. STOCK: No. That happens to be a tool that you would not pick up. For example, suppose you come in with a government job. We need an Ingersoll-Rand tool for it. My industrial engineer will note that, "We've got an Ingersoll-Rand in our plant." Well, that would not be a tool we would give back to the Government. That is one thing we will use over again in our plant.

QUESTION: But you got some of these tools on a rental basis, did you not?

MR. STOCK: We never get any small tools on a rental basis. We rent spot welders and some other equipment. However, there is a national tendency--I suppose you would call it that--among the machine-tool manufacturers to rent machines. At the end of five years, the machine is bought outright or it is given back. But ordinarily we do not rent any small tools.

Incidentally, I might point out that these figures are taken from an actual production job in our plant. We just picked one up.

QUESTION: You mentioned that you gauge all pieces at the machine before they go on to the next machine. This puts the burden on the worker to gauge, reject, or accept his own work. It seems to me that you might possibly run into some difficulty there. Would you mind telling us more on that?

MR. STOCK: It does, in a way, put the burden on the worker. On all our production lines we try to build our fixtures in such a way that the piece won't be accepted if it is not right. We cannot, of course, do that 100 percent. You saw this drawing of our layout, with the machines all lined up in a row. Well, if operator No. 5 makes a mistake on his jo

we try to build our fixtures in such a way that the piece will not go on to operator No. 6. However, in order to let that operator know what he is doing, we set a gauge at his machine.

He uses this gauge for checking the piece, and quality control also uses the gauge in checking the particular operation for statistical control purposes. We also have roving inspectors in the plant who check the part as the operation is performed. In our plant it is the duty of the operator and his group leader to make correctly the pieces while it is the duty of the inspector to find out if the pieces are correct. For this purpose the gauging is done by the Inspection Department and it is its responsibility to check the gauges for accuracy and to maintain them in good working order.

The gauge belongs to our Inspection Department; it does not belong to the shop. The gauge inspector is charged with the responsibility of seeing that the gauge is right. But it does put some responsibility on the operator. You see, we pay for only good pieces. If the operator makes them wrong, the man next to him cannot do anything about it. So in the final analysis all lose money. He usually wants to know that his piece is right--at least that is what we have found. That does not hold good entirely on our big machine-shop jobs. I do think the general feeling is there, though. Where we produce one or two different pieces, we don't have it broken down quite so fine as that.

QUESTION: I was quite interested in your comment regarding your taking a bid on an item which your company had never made before. Looking at it from the standpoint of producing for a possible future war, when there is apt to be quite a bit of it done, rather than have you disrupt your usual type of work, wouldn't you be able to produce more of your own class of item rather than something brand new?

MR. STOCK: I think that is 100 percent right. However, the existing facilities probably are not adequate to take care of all needs. Somebody has to get into it eventually.

If there should be a source of supply set up that is capable of producing an article and then Joe Doakes is told to produce the same article and furnish it to the original source of supply, that I think is out of reason. However, I know it is done. Everybody should build, if they can do it, what they are accustomed to building or what they have been trained to build. However, I think that the available outlets will not be sufficient to take care of all needs. So someone else has to get into it.

The only thing that I see in opening an additional source of supply is that something should be given to the man to give him a general idea of what it is all about. This should be done only in the interest of time and not in the interest of anything else.

In our own plant, we will try to find out how something is built. Oh, we might make a mistake or two, and lose some money on it, but at least we try to learn how it is done. For example, we will arrange for a trip to an arsenal. We will go there to observe a particular operation. You'd be surprised how good men are at observing an operation and then coming back and getting to work on it. In the final analysis, we will do the job quicker--and, I hope, better--because we have learned by seeing someone else do it.

QUESTION: Mr. Stock, one of the projects being contemplated today has to do with industrial mobilization planning. It is what is now known as the Production Allocation Program. Would you be in a position to comment on York's attitude toward it? Has your plant been surveyed? Would you like carrying out this plan in your plant? In other words, what do you think about the plan as a whole?

MR. STOCK: I don't know. I am not in a position to say one way or the other.

However, I might say one thing here in this connection. In our community we have what is called the "York Plan," where we pool our interests in order to get a job done. For instance, in the other war we took on the 6-inch barbette gun. We had the facilities to produce that right within the area, and we did. We have that plan instituted and working right within our own locality. I know there is a survey being made on the Government's end of it; however, I personally do not know too much about it. It has not been brought down to me at all.

QUESTION: Mr. Stock, would you say, from industry's point of view, it would be feasible, in implementing this industrial mobilization plan, to include during peacetime the requirement that as a part of its contract there would be prepared by industry an analysis for anything it built for the Government?

MR. STOCK: You want my personal view? I bow to you. I hope that analysis sheets will be made. I hope we have to make them. However, during the time we have now, there probably are not enough industrial engineers throughout the country to make the analysis sheets; they are essential, though. I would say definitely that during peacetime it shoul be done and wherever possible during this period of mobilization through which we are now passing. After all, these things are not all going to

be obsolete. Somebody else is going to have to build them. Our plant did that during the other fracas we had. We furnished the Government with analysis sheets, plant layouts, and so on. We wrapped the whole thing up in one ball of wax and furnished it to the contractor in booklet form so that future contractors would know what we had done. Our method of computing the overhead was excluded from it, but the machines we used on the job--the name of the machine and the size of it--and our method of operation were put in. Now, while it cost money, I think--in the long run, it will pay for itself a thousand times.

QUESTION: On your cost analysis summary I noticed you had some remark there to the effect "Total includes 50 percent of the capital cost of Cincinnati Broach." I wondered how much of the capital cost of the machines you charged each contractor. Were they spread over a long period of time? Did you charge more than the capital cost for those machines when they had been used on four or five contracts? Just how do you handle that?

MR. STOCK: No. That does not go into making up our overhead at all. The capital equipment is bulked. It goes in as a bulk item. This particular one was used on two different jobs, both of them running simultaneously. It was simply to give our Cost Department people an idea of how much to charge each product just as when we are prorating the tools and fixtures. That is the only time it goes in. If the Cost Department or the Engineering Department or any other department in our company asks for some item, to have an explanation of it, we put it in there.

We are set up departmentally. Maybe it's wrong; maybe it's right. But our company has departmental overhead. We charge as much for the man sweeping the floor as we do for the man running, say, a $35,000 machine tool. That is all right for our business. It is terrible, however, for jobbing business or subcontracting business. But, for our business it is all right. The machine referred to was shared between two different departments, as well as between two different jobs. It went into one department and from there into another. It was all done on a departmental basis. I do not know what department that referred to (indicating the chart) but it is the same over the entire plant.

QUESTION: Referring to the machine-load chart, you indicated or said that was based on a two-shift basis. Is that your normal period of operation?

MR. STOCK: Ordinarily, we do try to load our machines to work 16 hours a day, two shifts.

QUESTION: Do you have a rule of thumb as to the number of shifts you will operate? In other words, if you had to go on a three-shift operation, what would you gain? What is the difference between a one-, two-, and three-shift operation?

MR. STOCK: Well, we would certainly lose money. It is more expensive in our plant to run three shifts than it is two. That is made up for a lot of reasons which can be disputed. In our own plant we have an agreement with our union, first, that a man shall not work over five hours before he has a half-hour rest period or a half-hour for lunch. We have to pay him for that half hour if we work three shifts whether he works or not.

Then, too, we have extra supervision and facilities to take into consideration. We calculate 22.5 hours a day on a three-shift operation, not 24 hours. We know we are going to lose that much.

QUESTION: It has been said that if we set up our production lines on a single-shift operation and if we were to go into all-out production, we could triple production. Would you care to comment on that?

MR. STOCK: Production will not be tripled. If for no other reason, if industry runs one eight-hour shift, it will be able to operate X days or weeks without a breakdown whereas if it runs three eight-hour shifts per day, it can only operate one-third X days or weeks. Production certainly will not be tripled.

I do not have with me the figure you are hunting for, but it could be calculated very quickly. In our own plant we use 22.5 not 24 hours. That would be the first percentage we would lose. If we were running three eight-hour shifts, I am not an authority on this but I have heard that the chances of rejects are higher on some shifts than on others. However, we haven't found it to be that way in our plant. I do know the machine repairs will run approximately three times as great on a three-shift as on a one-shift day. There is a formula on that; however, I do not have it just now. We run three shifts a day only in a very few instances. We figure on 16 hours a day. We use the third shift merely to catch up and take care of minor repairs.

QUESTION: Do you compute production on the first and second shifts at the same rate?

MR. STOCK: The same rate; yes, sir.

COLONEL SEAWARD: Mr. Stock, you have indicated a little bit of the plant layout here, and the workload of some of your machines. How do they tie in together? To what extent will the plant layout affect production of a particular item?

MR. STOCK: It depends on the production of the item, that is, the amount of pieces involved. Now, on this particular item for which we made our load chart we had to make the load chart before we made the plant layout. We didn't know how many machines we were going to need. Remember, in the first chart the rate of production was given to us. If we were going to have an 80 percent efficiency, each one of these machines had to produce the production in 48 hours per week. If it wouldn't, we would require another machine. Some of these pieces are an identical operation on this particular layout.

We made a rough survey of the West York plant some years ago and determined that we spent 49 cents out of every dollar on materials handling. When we handle pieces, we certainly don't add anything to their value. It costs money. That was rather high. But considering the plant and the type of work, it is normal. I think in most plants of this type it runs from 40 to 50 percent. In this particular plant here we have about 7 percent materials handling. This includes delivering the pieces in and out and handling between machines and the shipping. That all comes in materials handling.

QUESTION: I assume these machines require a certain amount of maintenance. I was wondering whether you run a regularly scheduled maintenance program on them, or maintain them in the eight hours they are shut down and not in operation?

MR. STOCK: On processing equipment we generally know it is going to take some maintenance. We build that right into our rate structure. So that if this machine, for instance, runs oftener or longer, the maintenance man on the job makes a little bonus, too. We give him an incentive to keep his machines going. We have to clean out the tanks, scrub down the paint. We do that in the third shift or on the off hours. If we have no experience, we take maybe one or two percent. On some of the big machines it is a very small percentage. But on a high production press like a fin press, that is very intricate, we go up as high as 10 or 12 percent maintenance. That must be built into the load charts.

COLONEL SEAWARD: Mr. Stock, I am sure we have more of a right to lay claim to being industrial engineers after hearing you this morning. Thank you for a very interesting talk.

MR. STOCK: Thank you, Colonel.

(15 Mar 1951--650)S.