RESTRICTED

INTRODUCTION TO PRODUCTION

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INTRODUCTION TO PRODUCTION

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COLONEL CRANE: Gentlemen, this morning we start on a new subject in our curriculum at the College. In the next eight weeks you will be reading, talking, and discussing production; and it is pertinent at the start, I believe, to develop the exact purpose and objective of the production course, just what we are aiming at and what we hope to achieve.

As I said last fall in my orientation talk, the purpose of this course is not to make you production experts. Our purpose is to develop in you a basic understanding of the production process and an appreciation of some of the more important and outstanding production problems—all this as an aid to you in making a more realistic approach to the more general problems of industrial mobilization and economic mobilization, with the hope that in developing plans for industrial mobilization and economic mobilization you will produce more realistic plans.

A few weeks ago during the discussion period in this auditorium one of you raised a question about a lack of light mortar shells when a demand or requirement was set up for them in the European theater. As I recall the situation, the heavy shells had proved unsatisfactory and more light shells were needed. The requirement was passed back to the Zone of Interior and nothing happened.

I don't know the details of that particular case, but I would assume that production was a contributory, if not a primary, cause for that delay. The facts of the matter are that the two shells are made by entirely different processes. The heavy shell is made with seamless steel tubing, which is swaged at one end and cupped in a cupping press at the other, then machined to final dimensions. The light shell is made from bar stock and forged in an upsetter or forging machine, then machined to final dimensions.

Thus, assuming that the available capacity for the light shell was utilized to the fullest extent, the increased requirement for the light shell resulting from this unexpected demand involved the establishment of additional facilities for the light shell. As to material, since the seamless steel tubing which was on hand, could not be used bar stock had to be ordered. Presumably the bill of materials was available, but the requirements had to be presented to the Requirements Committee for allocation of the steel under the Controlled Materials Plan (CMP). After that

allocation had been made, an arrangement had to be made with the steel mill for the scheduling of the rolling of the bar stock, worked in with existing schedules; the actual rolling accomplished; and the material delivered. In so far as facilities were concerned, the upsetter is a rather heavy machine, with heavy castings and involving considerable machine work. It is a machine that is not stocked, but which must be built to order. Therefore there was a long delay in getting the castings and the necessary machine work to assemble the machines.

In the upsetter there are four stages where hot metal is formed, four punches and dies. Those punches and dies had to be designed and they had to be obtained by manufacture in a tool shop, which calls for very high-precision work. They had to be carefully heat-treated and finally proven to determine that they produced satisfactorily.

These are the elements which delay the fulfillment of an unexpected requirement which comes up, the production delays. Don't get me wrong. I don't feel that it would help the man in the field to do without these shells by knowing what is involved in getting them. I am very sympathetic with the position of the man in the field. I think it is the job of the logistic forces to furnish what is required. On the other hand, I do think that if the logistic planner had a proper appreciation of the production problems involved in the transition from a heavy shell to a small, light shell; if he had recognized that by providing sufficient flexibility in his plan through reserve capacity or some other means, realizing that he must be in a position to meet some unforeseen contingencies, I think then we would be nearer to meeting the problem of providing unexpected requirements.

Now, this all brings out the point which I am trying to establish here--that a knowledge of the capabilities and limitations of production is absolutely essential to the logistic planner. If he is going to make realistic plans, he must know what he can obtain and what he cannot obtain from production; and, if flexibility in those plans is needed, he must make provision for that flexibility. So that is our purpose in the production course--to develop an understanding and appreciation of what is involved in production, to facilitate your performance as logistic planners in the future.

There are numerous definitions of mass production. Seldom do we have exactly the same idea in mind when we are using that general term. I don't want to give an exact definition, because I don't want you to spend your time in quibbling about minutiae and details as to the exact definition you use. For our purposes, however, I think we should consider mass production as a method which has been developed in this country for the production of large quantities of products at low cost. I think that will serve all the purposes that we may have.

What are some of the significant characteristics of modern, mass production? I think it is essential that we should recognize just exactly what these characteristics are, because they enter into the problem of understanding what the capabilities and limitations are.

In the first place, modern, mass production makes extensive use of semiskilled workers. It makes minimum use of skilled workers and maximum use of semiskilled workers, the machine-operator type of workers. That is probably due largely to the economic reason that the wage scale of the semiskilled worker is much lower than the wage scale for the skilled worker or the craftsman. On the other hand, there are probably other reasons as well, an important one being that the number of skilled workers or craftsmen available is quite small. You can probably visualize where we would be in time of war if we had to depend upon the number of gunsmiths that were available in this country to manufacture our rifles and machine guns.

In the second place, semiskilled labor is extensively used because of the extreme inflexibility in the supply of skilled labor. An extensive training period is required to develop and train a skilled worker. Normally there is a period of four years of apprenticeship required. You can readily see that dependence upon skilled labor, with the extremely long period of training required, would make us extremely vulnerable in time of war.

Another factor entering into the inflexibility in the supply of highly skilled labor is the artificial limitations and restrictions which are imposed as to the number of apprentices which may be trained each year. You are all probably familiar with the attitude of organized labor on this point. It is merely a security provision, to insure that the supply available is not too great, so that it will not adversely affect their bargaining power.

Along with this extensive use of semiskilled labor we have another characteristic which is directly related to it. If you are going to use semiskilled labor instead or highly skilled labor, it is necessary to break the productive effort down into simple and elementary tasks which are capable of being performed satisfactorily by the semiskilled laborer. Thus we have another significant characteristic in modern, mass production where the entire productive effort is broken down into a large number of simple and elementary tasks.

As a result of these two things, the extensive use of unskilled labor and the breaking down of the effort into simple and elementary tasks or operations, we have a third characteristic, which is the extensive use of

complicated and automatic machinery and equipment. Here we think of the equipment furnishing the skill which has formerly been supplied by the skilled laborer. In other words, the skill which is built into the machinery and equipment supplements the limited skill of the unskilled worker to produce the result which the highly skilled worker formerly has produced.

That is accomplished in two ways. The first way is by special-purpose machines and automatic machines. These are machines in which the entire operation is automatically performed through cams and other mechanical devices, where the worker merely has to press a button, observe theoperation of the machine, and make sure that nothing goes wrong. He simply presses a button to start and presses a button to stop the machine.

For the general-purpose machines that additional skill is furnished through the aid of tooling. Tooling is necessary in the case of general-purpose machines in order to enable the semiskilled operator to produce a satisfactory result. That tooling consists of jigs and fixtures, which are nothing more than work-holding devices. These work-holding devices are attached to the machine and adjusted to the proper relationship with the cutting tool of the machine by a highly skilled man known as a set-up man.

After that adjustment all the operator has to do is to insert a piece in this work-holding fixture, clamp it, and push a button to start the machine; and the cut is automatically made in the proper relationship to the other dimensions. When the cut is finished, the machine operator stops the machine, picks out the work, inserts another piece, clamps it, and repeats the cycle.

There is one other necessary bit of skill required here to supplement that of the unskilled worker. Tools wear as they cut metal; and as the wear occurs, the relationship between the surface being cut and the other surfaces changes. Therefore the machine operator must be furnished with some device or tool to check and make sure that his machine is producing the way that it should. That is done by the use of gages. By the use of the gage the operator periodically can check the result of his machine and determine when it is approaching the maximum limit of variation allowed and can then shut his machine down and call for the set-up man to make the necessary readjustment to bring the result within the allowable variation so that he can proceed again.

Work-holding devices for operations other than drilling are usually called "fixtures." The term "jig" is applied to a work-holding device used for drilling holes. Just visualize an ordinary box with a hole accurately drilled in the top. Machine operator merely inserts a piece in

that box, or jig, clamps it in place, and positions the jig so that the drill comes through the hole in the top, which has been accurately located, and that produces a hole in the proper relationship in the piece directly beneath, without the necessity of measuring and locating that point on the working surface.

Those are all aids or supplements to the skill of the unskilled worker. I have already mentioned punches and dies in the case of forgings. Dies are merely carefully developed devices in which the desired shape or form is recessed in the working surface of a steel die block. A hammer or press forces hot metal into the recess and the metal takes the form of the die, thereby giving it a predetermined form without any action on the part of the operator except to operate the hammer that comes down on the hot metal and squeezes it into the die.

All these devices are what is known as tooling, the necessary tooling for the job. As I said, they are supplements to the skill of the unskilled machine operator, to enable him to produce work of satisfactory quality.

Now, the fourth significant characteristic in modern, mass production is interchangeability of parts. We normally think of interchangeability of parts as being related to the service function, to the maintenance and repair of the material after it is put in use. However, interchangeability of parts is a very essential part of modern, mass production. I think you can readily see that in the assembly of this material, if you are going to use workers or laborers of moderate skill, semiskilled or unskilled workers, you have to eliminate all fine adjustments and the fitting of the parts at assembly. Therefore, if you are going to utilize unskilled labor on the assembly process, you must make the parts interchangeable, so they will fit without any adjustment at assembly. If there is not interchangeability, you require a worker with a very high degree of skill to make the necessary adjustments to fit the parts together.

Let me just summarize, then, those four significant characteristics which I have mentioned. The first is the extensive use of semiskilled workers. The second is the breaking down of the productive effort into elementary tasks or operations, into simple tasks. The third is the extensive use of complicated and automatic machinery and equipment. The fourth is interchangeability of parts.

Now, those four lead to another significant characteristic, which to my mind is the most important from our point of view; and that is that modern, mass production involves detailed and time-consuming preparation.

In order to provide these things, extremely detailed and time-consuming procedures must be gone through to make ready for the production. We sometimes refer to that as production engineering, but in general the problem is to plan in detail just how the job is to be done. And when I say "in detail" I mean in detail, step by step, for each part involved.

After the plan has been developed, there must be designed, manufactured, and installed all the necessary equipment and machinery required to do the job according to the plan. Finally, after this has been installed, there must be a follow-up to insure that the machinery and equipment which have been provided produce in accordance with the plan, following through to make sure that all the bugs have been eliminated, so that the processing proceeds smoothly and without any difficulty.

Now, in contrast to the actual production process, which uses a large proportion of semiskilled or relatively unskilled personnel, this preparation requires the highest degree of skill and technical knowledge. The make-ready period is entirely dependent upon personnel who have a very high degree of training and technical skill.

First of all, there are the production engineers, who lay out the jobs and plan them. Second, there are the machine-tool designers and the machine-tool builders, who take the requirements, usually in such broad terms as "We want a machine to do this at a certain production rate and to be handled by one machine operator" and proceed from there to produce the desired result. Then there are the tool designers and tool makers, who are responsible for taking the broad, general requirements of the work-holding device and developing a detailed design which will operate satisfactorily; and then actually fabricating it so that it does produce as intended. Finally, there are the gage designers and the gage makers, who are very similar to the tool makers except that they work to far closer tolerances and therefore require considerably more skill and experience. I want to emphasize this point. Although in the actual production process you rely largely on semiskilled workers to produce the material, during the preparatory stage or the make-ready stage you are absolutely dependent upon highly skilled and highly technical workers.

Now, let us consider for a minute just why it takes so long to make ready for production. I would like to review briefly the steps which are involved in the preparation for the production of a new product. This has a direct bearing on our problem, because in the vast majority of cases the products that the military wishes industry to produce are new products to the industry. They are products with which industry is entirely unfamiliar and have had no previous experience.

The first step for a manufacturer to take in preparation for the production of a new product is to analyze completely the product part by part. The first decision he has to make is what parts he will manufacture himself in his own plant and which parts he will procure by subcontract from outside sources. The considerations involved there are largely economic under normal conditions—which is going to cost him the least money. But certain other considerations enter into it—as to whether the necessary skill and technique is available within his organization to manufacture this part; whether the necessary facilities are available; whether the quantity is large enough for him to set up a new department within his organization to produce it profitably. It is a rather complicated subject. I have just indicated some of the considerations. But, before he can go any further, he must decide what he will manufacture in his own plant and what he will procure from outside sources by subcontract.

Once he has decided on what he is going to manufacture, the next step is to decide just how he is going to manufacture each part. By that I mean, what are the successive steps that he is going to take, for instance, for a certain part, starting from the raw material and going through the successive steps that will be taken to finally end up with the finished product as shown by the detailed drawing.

Now, that process is known as making out a list of operations for each part. The list of operations shows in detail what the operation is. It shows the operations in sequence. It shows the material to be used, how much is required and in what form, whether it is bar stock or a casting or forging. Then it says, "The first operation will be to do this and the second to do this" and so on until all the operations have been completed and the product conforms to the shape called for in the finished drawing.

In the list of operations all operations are listed in sequence. For each operation the particular type of machine tool that the operation is to be performed on is indicated. The general type of work-holding devices or special tools, fixtures, gages, and so forth are indicated. There is also an estimated machine time for the operation.

When the list of operations is completed, that becomes the bible. It is the specific plan showing in detail for each particular component to be manufactured exactly what the successive steps are, what machine tool is used, what work-holding fixtures, what gage, and the estimated machine time.

Now, with the list of operations as the basic plan, subsequent steps proceed concurrently along several lines. The first step that we will

consider is the tooling. The list of operations indicates merely the general type of work-holding device which will be used for the operation. The tool designer takes the list of operations and works out in detail the exact design of the work-holding device and details it on a drawing. He has to consider the design also in view of the successive operations and the changing shapes that the piece will take on in those operations.

That is a rather complicated procedure. Let me give you an example of the number of operations involved in a particular component, the receiver of the Springfield rifle, 1903 model. In that receiver there are 117 operations from the start to the finish, from the forging of the material to the metal finishing. If any of you are interested in getting a better picture of just what is involved, there is a book in the library by Colvin and Vial which contains all the operations on the Springfield rifle. If you are interested, just take a look at it. Don't try to read through it. Just look at it and get an idea of the complexity and the amount of detail involved in setting these things up.

As soon as the tool designs have been completed, they are immediately released for manufacture to the tool room in the plant, or are farmed out to an outside tool shop. Here again the considerations involved are the question of control, the question of capacity, and the question of time. An over-all time schedule is set up. If the capacity in the plant tool room is inadequate to meet that schedule, outside tool shops must be utilized in order to get all the tooling done according to schedule.

Now, concurrent with the design and manufacture of the tooling is the determination of the machine-tool requirements. The list of operations contains the estimated machine time for each operation. By consolidating and adding up all the machine times for a given type of machine, the total machine hours required to do the job are determined for each type of machine tool. Then by inventorying the machine tools in the plant and the number of machine-tool hours available for work in any given month, the total number of available machine-tool hours may be computed. Of course, the difference between what is required and what is available is what must be supplied by additional machine-tool equipment.

After that has been determined, sources of supply must be located, orders placed, and continued follow-up provided to secure the best delivery date for the new equipment.

As soon as the machine tool requirements have been determined, the problem of rearrangement of the plant layout for the production of the new product must be solved. That is a rather involved and tremendously detailed operation. Generally, scale models are prepared for all machine tools and equipment and various arrangements are studied and analyzed in

order to attain an uninterrupted flow of material from the receipt of raw material to the assembly and the shipping. The whole idea is to avoid unnecessary handling. It includes provision for a continuous flow of materials and for the necessary material-handling equipment in order to keep the material flowing.

It also provides for a close integration with the assembly lines, that is, for a crossflow of components entering into the assembly line at the proper points where they need to be incorporated in the assembly and to avoid unnecessary hauling and backtracking. That is a very detailed procedure. It is an extremely interesting one, as approached by industry.

Also concurrent with this is the preparation of the bill of materials from the list of operations. That is merely a compilation of the total requirements of material needed to produce everything that has to be produced and at the production rate desired, showing the specific form required, whether bar stock, forgings, castings, or what not.

The next problem is to locate sources of supply and place orders for this material. I have assumed that no orders for parts which are not to be manufactured have been placed. So that also comes in here. Sources of supply must be located and orders placed for the parts that are not to be produced in the plant. Sources of supply must be located and orders placed for raw materials, for castings, and forgings if no capacity is available in the plant. The effective follow-up must be established to insure that there is no tie-up, that there is no delay in delivery.

All this, of course, has to be carefully coordinated. A schedule has to be set up with proper coordination and control to insure that these things all come out together at the same time, so that you will be all set to start production. That coordination and control also involve follow-up and chasing around to the machine-tool builder and the tool maker and the raw-material suppliers in order to insure the furnishing of materials as required.

Let me summarize again the important points involved in the preparation for the production of a new product. First is the complete analysis of the product and its components part by part, the determination of what is to be manufactured in the plant, and what is to be purchased outside. The next step is the preparation of the list of operations, which is a detailed plan as to how each component is to be manufactured. The next step preceeding from there is the tool design and the tooling procurement or manufacture, the determination of the additional machine tools required and placing orders for them, and the determination of the material requirements and placing orders for them.

Now, what has all this to do with our problems that we are interested in here? To my mind it is one of fundamental interest to us, because it runs through all production problems. It is not peculiar to any particular type of product.

It is also extremely important because the one thing that we are concerned with at the present time is the formulating of plans, devices, and procedures for saving time. We are working against time. Preparation for manufacture is a detailed and time-consuming thing. It is the most fertile field for saving time; therefore, the most fertile field for industrial mobilization planning and economic mobilization planning where we have an opportunity of really saving time and accomplishing something.

Also it serves another useful purpose, because it provides a yardstick for us to measure or evaluate proposed paper plans. Certainly if you know what has to be done, you can tell from the plan actually what has to be done, you can tell from the plan actually what has been accomplished toward that end. If everything remains to be done in the future for preparation, your paper plan is worthless, because you haven't accomplished a thing so far as actually saving time is concerned. It helps you to understand the proposals and measures which are taken and to evaluate them.

I don't want to appear as opposed to this. But let us take the JANMAT Plan for establishing a machine tool reserve. To what extent can we expect this action to expediate production? Of what value is it going to be?

I want to suggest to you that possibly the procurement of machine tools may not be the determining factor. It may well be procurement of tooling. The machine tool without the tooling may not improve our position, may not save us any time. The two work together; they are complementary. I am merely throwing out to you the point that an understanding of this procedure is necessary to evaluate properly plans and procedures which are proposed and that it will be absolutely essential in your work of developing these procedures on a realistic basis.

Now, let me summarize briefly what I have covered this morning. First of all, the purpose of the course—let us keep that purpose and objective clearly in view. Let us keep on the beam and not go off on a tangent. The purpose is to get an understanding and appreciation of the production process and production problems, the capabilities and limitations of production, so that we may approach the problem of industrial mobilization planning more realistically.

There are certain outstanding and significant characteristics to mass production which we should remember as an aid in accomplishing this purpose; namely, the extensive use of semiskilled labor, the breaking down of the productive effort into simple and elementary operations, the use of complicated and automatic machinery, and the interchangeability of parts. Finally, and most important of all, there is the detailed and time-consuming preparation required in making ready for the production of a new product under mass-production conditions.

Then finally in breaking down this preparation into essential parts there is the preparation of a list of operations, which is a detailed plan for accomplishing the work; second, the tool design and the manufacture of the necessary tooling, jigs, fixtures, dies, gages, punches, and the special tools for use with the general-purpose machines; the determination of the machine-tool requirements, obtaining the necessary machine tools to supplement the existing machine tools; and finally the bill of materials, which is the basis for placing orders for the necessary raw materials to accomplish the job.

I think that if you will keep those things in mind as you proceed with your study and thinking on the problems which are presented to you in the problem directives, you will be able to be much more realistic in your approach and more practical in your solutions.

Finally, it will enable you, as I said, to evaluate proposed plans. That, of course, is the big purpose in the seminar group—to pick these things to pieces and made sure that they are practical and realistic. In other words, gentlemen, I feel that this is the real backbone of the whole production course. It is something that should be thoroughly and clearly understood by everyone before we start.

We have included in the first part of our curriculum book a section entitled "Production Engineering Fundamentals," which is a reprint through the courtesy of McGraw Hill of a very concise and clear outline of the various steps involved. It covers a little bit more in detail the matters that I have covered. I have merely repeated it because I want to emphasize and make sure that it is clear that that is the keystone on which depends your proper understanding of the production process, and understanding which is essential for effective logistic planning. Thank you.

Are there any questions? (No questions.)

(17 February 1948 — 450) S.