ORIENTATION AND FUNDAMENTALS OF PRODUCTION

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COLONEL CAVE: Fellow students: After listening to your oral presentations of the last few days, I feel that you probably need no introduction to "Production" for that is what this talk of mine really is. You have certainly proven that any attempt to separate sharply one unit of the curriculum from another is well-nigh impossible. But with this bow to semantics, I would like to pause for a moment and review some of the parts of our course at the Industrial College in the light of our present position at the start of this Production Unit.

For a few moments, let us consider these elements of our year's course from the standpoint of production. Let us look at all these other elements in their relation to production.

Chart 1, following page.--Here are some of the subjects which enter into broad military strategy. These all relate to our subject of "Production."

I think we here in this room can agree that we are not industrial producers and but few if any of us ever will be. But war and strategy today are inextricably bound up with industrial life. We depend on industrial production and if we are to do our military job, we must understand something of the civilian production task.

Admiral Connolly touched on this in writing the lead article in this month's Naval Institute Proceedings. He says that "Readiness should be included as one of the principles of war." By readiness he says he means "strategic logistic preparedness"--this in turn means a fast start in production.

In short, war demands production as well as fighting. And war absolutely demands coordination of military and industrial effort--as a team job. Now, since the spirit of teamwork is a respectful understanding of the other fellow's side, we are going to try, in this Production Unit, to obtain an understanding of the production side of the military-industry team job.

We've been told again and again how the United States with less than 10 percent of the world's resources, produces almost one-half of the world's goods. This production is our subject. How do we do it? The pat answer is, "Because of our productivity." Well what is this productivity? What does it consist of? How is it really put together? These are some of the questions we intend to get to.

However, there is another aspect of the Production Unit which should not be overlooked. You and I have also heard that we in the military

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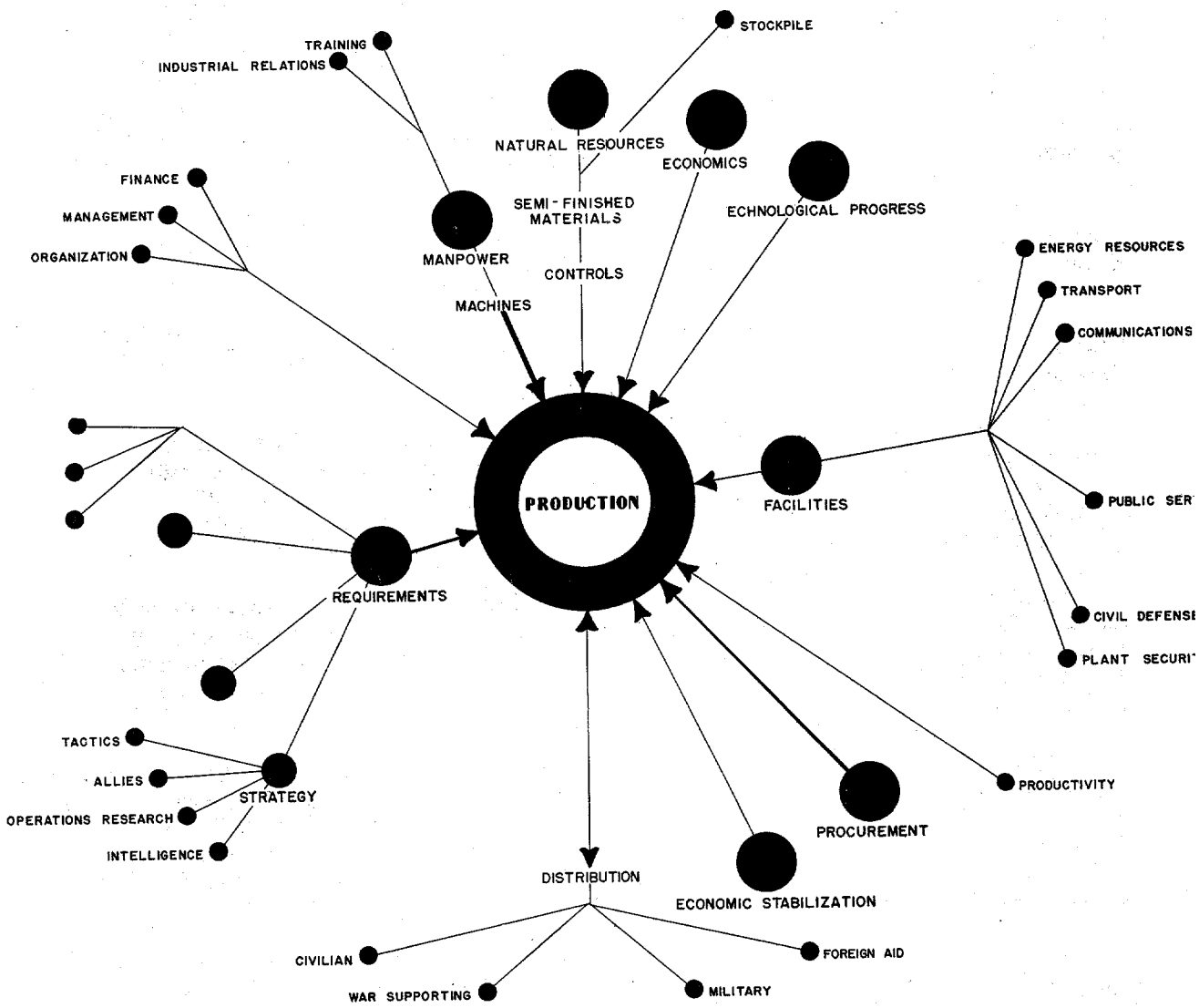
CHART 1

ECONOMIC MOBILIZATION



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should get some "industrial management and efficiency" into our operations. Now it is not my intention to go into detail on this subject, but in this course we're starting, you will have an opportunity to examine this challenge. This opportunity will come with some of our speakers, some of your reference reading, and some of your seminars.

These in turn will lead you to what has been called "a visual aid" for the entire year's course--the field trip in the spring, the week of 4 May 1953. We hope that the Production Unit will not only remove much of the mystery and explain much of the jargon of production but we also hope you will find it profitable, interesting, and enjoyable, too.

Now, as to this talk this morning--my remarks are intended to be a framework for your approach to production. I make no pretense of presenting you with any startling new facts. I shall pull a few familiar ideas and facts into a somewhat different relationship from that you've had in the course.

First, I shall further define and limit our field of the Production Unit with the aid of another chart.

Then, I shall go over some of the important factors and their relationship to the serialized production process.

We shall then look at an 18-minute motion picture. It will visually summarize most of what I have covered.

Finally, after a break, I shall take a few minutes for some remarks about the assigned problem areas of the Production Unit.

Production is a big word. It means many things. It can include the growing and harvesting of all kinds of crops: food, forest, animal. These are important parts of production but fortunately, this country of ours is, by and large, blessed with so much of these vital products that, generally speaking, production of food, fish and animal products, lumber, and textiles is not now for us a severe limiting factor in war production. I will not discuss them this morning.

Production can also include the mining and refining of raw materials from the earth. This is vital too. But it is not very close to our military contact with industry. So I will skip this in my discussion.

What I will discuss is the serialized production process--we generally talk about it as mass production; it is the most complex of all. Serialized production has been defined as "the continuous manufacture of large quantities of a single product." It is the kind of production that bears most closely and most frequently on the industrial availability of military end items.

Let me move over into this civilian industrial effort and take a look at it from the standpoint of industrial management.

Chart 2, following page.--Here are most of the important factors as they impinge on civilian industrial management.

We must recognize that although many of the elements of our Economic Mobilization Course are the same elements that concern industrial management, there are some which are vital to them and which we pass by in the Production Unit. Some of these are sales, competitors, business finance, and of course monetary profits.

What is more, you will find some industrial elements here which mobilization history has proven to be severe limiting factors to military effort. These have found their way into prominent places in our course. Most notable is of course materials: critical materials, strategic materials, the national stockpile.

In the Production Unit we will deal mostly with the top half of this chart. We must not forget for a moment that industry is very much preoccupied with the elements in the lower half--and with others as well.

Let me come back now to this so-called mass production. To my mind, there is a key to the understanding of serialized production. This key applies to products from the smallest and simplest up to the big complex ones such as Clay Bedford's building a ship in four and one-half days for Kaiser at the Richmond yard during the war.

The key is the bringing to a focus on a proposed product of all the engineering, technical, and managerial skills available. This has three principal objectives:

First, to break the product down into parts that will fit the manufacturing capabilities--in the time required.

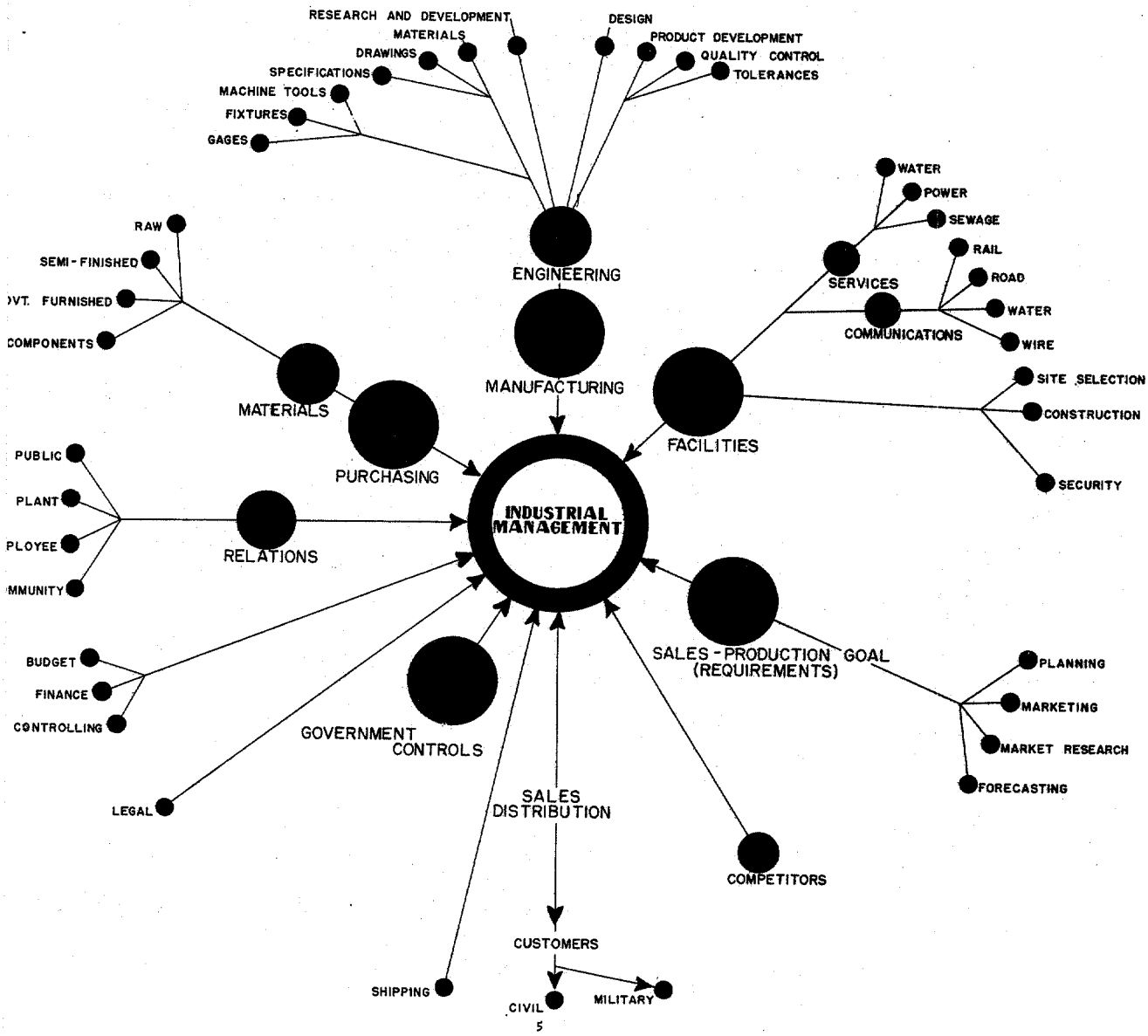
Second, to assess these manufacturing resources, both in amount and in quality, that is the men, machines, material, methods, facilities--that can be made available.

Third, to plan the group teamwork that will create the product. If the breakdown of the product is not adaptable to the manufacturing resources, then changes may be necessary.

These changes might be simple process changes, stampings for castings, steel for aluminum. They might or might not affect the utility of the development model or prototype. If such changes do affect the use and technology cannot meet the situation, then the planned use as expressed in military characteristics might have to be changed.

CHART 2-

CIVILIAN INDUSTRIAL EFFORT



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It takes a lot of judgment and close liaison between the research and development engineer and the production engineer at this point. It should be emphasized that this liaison does not and should not have to wait until this point in the time sequence. It should be going on back in the development period.

There are a host of implications to these facts but we'll spend no time now on the research and development phase.

Let us take a brief look at one important aspect of this production side. It follows logically and actually that a proven, fully acceptable, producible product that is made by one manufacturer cannot necessarily be duplicated or possibly even satisfactorily made by another. Why? Because his resources are different. Such differences are usually in his organization: his management, know-how, or most commonly in his facilities--machine tools and tooling. An example of this was the manufacture of a breech ring for one of our guns. By one method, this used to take 45 hours on 21 different machines. By using a broaching process, the time was reduced to 15 minutes on only four machines.

If a manufacturer's means are different, and his methods too, his costs will also be different. In short the same product usually presents a completely different production problem to every manufacturer. It will also present a different problem to the same manufacturer at different times. This is because of changes in his plant--almost day-to-day changes in machines, tools, equipment, and layout. This is the nub of the production problem threatening us tomorrow--the problem of gradual plant obsolescence versus instant readiness.

In order to get a good look at the elements of serialized production, let us first check off some of its basic characteristics.

Characteristics of modern mass production.--There are at least five of these, as follows:

1. Break down productive effort into simple elements.

2. Extensive use of semiskilled and unskilled workers.

3. Extensive use of complicated and automatic machinery and equipment.

4. Interchangeability of parts. (These four characteristics lead to a fifth and most important.)

5. Highly detailed plans and organization.

And let us never forget the all-important factor--time.

A word about number four, interchangeability of parts--in the United States Eli Whitney was the one who first successfully applied the idea of interchangeability back in 1800 when he produced 10,000 muskets. It can be said in passing that Eli was plagued during his tooling-up period by demands for production.

Now let us get a step closer to the breakdown I mentioned a few minutes ago. A breakdown into simple elements is for the purpose of analyzing the development design:

1. Consider "requirements": (a) how many? including spare parts, (b) starting when? and (c) at what rate?

2. Consider "production capability and availability": (a) raw materials; (b) machines, tooling, and gages; (c) facilities; (d) materials-handling equipment; (e) standards; and (f) manpower available.

This is done in order to arrive at the production design; including: (a) drawings; (b) specifications; and (c) plan for manufacture, inspection, and testing.

This is the problem which production engineering must attack and it is a team job for it draws on many skills. It requires the following:

1. Civil engineers for plant construction.

2. Electrical engineers for power and lighting.

3. Sanitary engineers for service facilities.

4. Chemical and metallurgical engineers for process analysis.

5. Ceramic engineers for refractory problems.

6. Transportation engineers for materials storage and handling.

7. Methods for process and equipment layout.

8. Safety methods, equipment, and health hazards.

9. Legal adviser at every stage.

10. A quality control consultant on all phases.

Now let me say a few words about "production capability and availability."

As we've said, the starting point for this production engineering operation is an acceptable development model. For military end items this model has met the military characteristics and presumably it can be produced in quantity. This is sometimes a big presumption.

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Sometimes the starting point is a production item and the problem is to produce it more cheaply or in greater quantity; or to use different machines, materials, or better methods. Possibly the problem is simply one of incorporating new model changes. This is a subject in itself.

New model changes are commonplace in the automobile industry. But even in this industry such a repetitive job as design, production engineering, and manufacturing of new models has not been reduced to routine procedure. Once management has decided to make a new car, a considerable portion of the organization launches into what has been called "one and a half or more years of organized chaos." This is the "make-ready" period.

"Make-ready" is the time needed for physical preparation of plant and facilities prior to the start of manufacture.

"Tooling-up" in this "make-ready" operation is the designing, making, and installing of ready-to-operate machine tools. These tools must then have initial production runs to prove that they can produce at required tolerances--tolerances frequently measured in ten-thousandths of an inch.

Depending on the market at the time, it may take from 6 to 18 months or even more to get the machine tool. A word about machine tools--essentially they are the machines for making machines; they do it with simple operations or combinations--turning, drilling, grinding, milling, planing.

A general-purpose tool such as a lathe can perform one operation, turning, on many kinds of jobs.

A special-purpose tool performs a combination of these basic jobs at the same time and in a sequence. The most complex tool is but a coordinated means for doing a number of these basic general-purpose machine tool jobs over and over again. Without such tools, modern serialized production is unattainable. Until production designs are established, these tools cannot be made. Here is a recurrent source of industrial mobilization bottlenecks.

Sometimes I think we get too concerned in the wrong way about our shortages. We find that we don't have enough materials or we don't have enough men. This is a plain fact. We rarely have enough when we hang on to old methods. The challenge to management is to find better means and better methods. Here is one more example from the last war of how industry solved such a problem by using new techniques in production.

You probably already have heard something of the manufacture of seamless steel tubing. Guns, which are also tubes, were not made this way. They were made from forgings. This means taking a big ingot and cutting off much of it, then forming it into a cylinder, boring a hole out the middle and rifling it; it takes time, machines, man-hours, and it takes a lot of material that must be thrown back to scrap.

During the war, there was a company that found it could use the seamless steel tubing method to make guns. The job of forging and machining gun barrels used to take from 720 to 15,000 man-hours, depending on the caliber. By using the seamless steel tubing method the time was cut down to as little as one-half man-hour in one case and 20 man-hours in others. That does not say anything about the machine tools that were saved or the materials that were saved. Most important, the figures themselves do not emphasize the importance of the man-hours that were saved. Yes, the type of tools and methods to be used has terrific leverage in determining our manufacturing requirements.

Now, to get back to this production engineering problem, we may expect to find a high order of efficiency in this operation in the automotive industry. A closer look at one of these automobile design changes shows first, that a car may have as many as 16,000 parts. Although perhaps 90 percent of the machines which made them need not be changed, more than half of them require new tooling--new fixtures, jigs, gages, and other equipment. Some of this equipment was small and others were extremely large, but almost 1,000 machines had to be relocated and 2,500 new dies and fixtures obtained. It took over two years and cost about 16 million dollars.

Yes, this production engineering or make-ready period is not easy. It is time-consuming and required great attention to detail.

But there is a payoff. A payoff in volume and quality and cost. Here's a military example.

The Thompson submachine gun--familiar to all of us--had about 20 years of development behind it. It had 73 parts in it. It was complicated. These things show up in the cost. The initial unit cost was about 200 dollars. What is more its complexity made it unreliable in action and time-consuming in training and maintenance. If we ignore its undesirable operating characteristics, and that is hard to do, we simply couldn't live with it in mass production.

What was the answer?

A proven skilled production unit, one that had never made a gun, was given a contract.

You saw the answer at Aberdeen last fall, the M-3 submachine gun; you saw how well this so-called grease gun fired after exposure to water, dust, and mud. These were desirable improvements in military characteristics--but you didn't see the small number of parts, mostly stampings--and it performed in a highly superior manner as compared to the Thompson. The cost was less than 20 dollars.

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This is why I speak with emphasis on our need to know something of production engineering. It has terrific military implications.

Now after all this analysis is done in looking over a new product we must set down in detail, precise detail, how each part is to be made, as follows: (a) what material, (b) how is it to be worked, (c) on which machine, (d) with what tools, (e) checked with what gages, and (f) in how long a time.

This might be a good point at which to say a few words about gages. Gages are simply special kinds of measuring tools. Their use by the workman helps him get the precision and uniformity needed for interchangeability. Gages are the tool of inspection. They are actually precision instruments. They take time to design and a longer time to manufacture. They are so vital to the process and you will see them so frequently this spring that we have scheduled a full period for discussion of them. Day after tomorrow at 10:30 Mr. Clifford Kennedy of Federal Products will show you most of the things you should know about gages.

Another very important subject closely associated with standards and gages is quality control. This "quality" in the expression "statistical quality control" is not quality in the sense that a Pierce Arrow was better than a flivver. It is quality in the sense of ability of a product to conform to the characteristics that have been specified. Statistical quality control has been said to be "one of the sharpest management tools developed in half a century." Quality control has been called a "combination shore patrol, MP, and G2." Now quality control might be called a logical development or by-product of inspection. This new science came about through the application of mathematics and statistics to the problem. Inspection rejects products after defects occur, quality control, on the other hand, through a coordinated and systematic use of process information prevents the defects from happening in the first place.

Because of its importance we have asked you to read Dr. Juran's lecture on "Quality Control and Inspection"; it is one of the few pieces of essential reading in this unit. Tolerances, gages, inspection, and quality control are very closely related. What is more they bear directly on costs. Dr. Juran has said that "he who sets the tolerances decides the costs." This is a most important point for us to remember.

However, to give you a full presentation of quality control, we have asked another speaker to talk to you and present his company's program. This will be in the middle of February.

In short, quality control is important to all of us, it is a highly developed scientific method but not too hard to understand. It helps us get the uniform quality and interchangeability we simply must have.

So much for my list of operations requirements. There are others but those I've mentioned are generally the most important.

Next we can "consolidate" our operations:

Consolidate Operation List

1. Determine and obtain machine tools required.

2. Release designs for manufacture or purchase of: (a) tools, (b) fixtures, (c) jigs, (d) dies, (e) punches, and (f) gages.

3. Bill of material--release for purchase with deliveries scheduled; this includes the components that are being subcontracted and not produced by the prime contractor.

4. Materials-handling equipment.

5. Inspection, test procedures, and requirements.

6. Plant layout.

Let me summarize what I have said with an industrial motion picture. It has been selected very carefully. It is squarely on our morning's subject, and it is concerned with a military item. What is more important, it will give visual emphasis to most of the points I've made and to many that I've not had time to make.

The motion picture "American Miracle" (Signal Corps, U. S. Army, No. Misc 7784) was shown.

Now let me summarize what I have had to say about these fundamentals of serialized production with four main points:

One, this serialized production is not the only kind of production in which we are interested. It is the principal kind that bears most closely on munitions availability.

Two, its fundamentals are relatively easy to grasp. But I know you will not mistake the elements of this complex operation as being elementary.

Three, let us always remember that under the terrific pressures of industrial competition or war there is continuous change in the tens of thousands of minor factors that make up the: (a) materials, (b) machines, (c) methods.

And finally, the whole effort is as complex as human life itself. To succeed it must have the kind of coordination that takes real moment-to-moment team effort on the part of all of us.

(29 Jan 1953--750)S/ss