MEASUREMENT OF INDUSTRIAL PRODUCTIVE CAPACITY

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MEASUREMENT OF INDUSTRIAL PRODUCTIVE CAPACITY

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COLONEL CRANE: Ladies and gentlemen: One of our basic problems is to determine the productive capacity of the country as a basis for formulating plans for industrial and economic mobilization. In total war, what can be produced establishes the ceiling for our requirements. A realistic rather than a "horseback" estimate of productive capacity is necessary to determine what additional facilities we shall need in an emergency.

This afternoon we are extremely fortunate in having an outstanding industrial engineer discuss this problem for us. His knowledge in this field is backed up by many years of experience, and his judgment is accepted by practical and realistic businessmen and bankers in industry and in investment.

It is a great pleasure indeed to present to you this afternoon Mr. George S. Armstrong.

MR. ARMSTRONG: Colonel Crane, ladies, and gentlemen:

Your Commandant, Brigadier General E. R. McKinley, and his associate, Colonel R. Z. Crane, have extended a cordial invitation to me to address you on the subject of the "Measurement of Industrial Productive Capacity." From our exchange of correspondence it was evident to me that these Officers fully recognized the real problem and difficulty involved in any such measurement.

At the same time I understand how from the viewpoint of the Armed Forces nothing could exceed in importance an attempt to formulate sound and practical procedure for the determination or establishment of dependable indices of productive capacity.

Schooled for many years as I have been in industry I can assure you of my sympathetic understanding of their and your interest in this matter and also of my knowledge of the complicated and variable factors which must be considered in any such undertaking.

It occurs to me that it might be well before mentioning to you the principles and methods which might be employed in the measurement of productive capacity in any specific case to develop first certain general conditions and circumstances which bear not only on the over-all productivity or capacity of our country but also on any one individual plant or productive operation.

Fundamentally, industrial productive capacity is the multiple of a number of basic factors or elements, both physical and human. It is essentially a compound of the energized actuation of machinery, equipment, and tools applied or operated by humans manifesting wide variations in the ranges of their individual skills, experience, and diligence, working under the control or direction of supervisory management comprised of comparably wide ranges in ability and executive capacity either as individuals or as a group.

In addition, and as an imponderable element in this aggregate compound there must also be considered the physical and chemical characteristics and the variations therein of the raw materials which are the subjects of this application of power, machinery, equipment, labor, and management.

The reference to energy, in my opinion, is highly significant. While we hear of war as a combat of metals, oil, rubber and many other essential raw materials and of the products made therefrom, it can not be emphasized too strongly that the stocking and continuing supply of our arsenal of war today depend indispensably on an adequate supply of energy.

The importance of a sufficient supply of energy can be developed by consideration of certain over-all statistical compilations of our economic and productive capacity, with which I am sure you are familiar. These are designated as the Federal Reserve Index of Industrial Production and the estimates of the annual aggregate of our national income and gross national product expressed in terms of dollar values.

On the basis of taking the period from 1935 to 1939 as 100, the Federal Reserve Index of Industrial Production registered a peak of 239 in 1943. It declined somewhat in 1944 and 1945 and stood at 170 and 186 in 1946 and 1947, respectively. The estimates of aggregate national income and gross national product reflect changes in the value of money as well as in the volume of actual physical output. Nevertheless, such estimates are significant and it is appropriate to mention one of them, gross national product. The aggregate of this statistical estimate amounted to 232 billion dollars in 1947, which compares with 103 billion dollars in 1929 and 192 billion dollars in 1943.

At this juncture it is appropriate to mention and illustrate the contribution made to our national output by the availability of an adequate supply of energy or power. Briefly and expressed in units of millions of KW hours, our output of electrical energy increased from 96,000 in 1929 to 231,000 in 1944. The correlation of this increase in the output of electrical energy to that of our productive capacity may be seen by converting such energy to an index basis comparable to that on which the Federal Index of Industrial Production is computed.

Such procedure shows the following comparison.

Comparison of Output of Electrical Energy and Industrial Productivity On an Index Basis
1935-1939 = 100

Year	Electrical Energy	Industrial Productivity
1929	83	110
1944	199	235
Increase 1944 over 1929	2.4 times	2.1 times

From these data it may be seen that the large increase in our productive output was made possible by a concurrent output of electrical energy with the attendant necessity of the provision having been made prior thereto for the installation of the additional generating capacity required for any such service or demand.

In this connection it is interesting to note that the index of electrical energy output in 1944 was approximately 2.4 times that of 1929, as compared with the relationships of industrial productivity on an index basis which in 1944 was 2.1 times that of 1929.

Relating the output of power to the aggregate of the estimates of national income and gross national product, it is interesting to note the definite conformity evidenced throughout the years by the ratio of KW hours of electrical output per dollar value of national income and gross national product.

Specifically in 1929, 1.1 KW hours of electrical energy were produced for each dollar of national income which compares with 1.3 KW hours per dollar of such national income in the year 1946. Since in the case of gross national product practically the identical characteristics are found, it seemed to be an unnecessary repetition for me to submit the almost duplicate statistics in that regard.

However, the factor of labor and labor productivity is closely correlated with the production and use of electrical energy. To illustrate, in 1929 approximately 3,000 KW hours of electrical energy were produced for each employee engaged in nonagricultural pursuits. This consumption of electrical energy per employee has increased progressively and in the year 1946 amounted to 5,485 KW hours, or an increase of 82.8 percent over 1929.

Labor, as you well know, is an indispensable component of productivity and one, as with all things human, which is subject to the vagaries of incentive and motive, or the psychological factors, as well as of the inherent skill and industry of the individual. One of the more promising aspects of the vast economic power of our country is the manner in which both machinery and equipment and the methods employed in practically all industries have lightened the burden of physical effort by workmen and thus facilitated their effectiveness in terms of output per man-hour.

While, admittedly, there are many defects and margins of error in any measurement of industrial output per man-hour, the general over-all magnitude of such output in aggregate and the essential accuracy of the predominant factors in any such estimate, permit, it is believed, acceptance and reliable interpretation of such statistics which, as you know, are compiled by the Bureau of Labor of the United States Government.

On an index basis, taking the year 1909 at 100, the output per man-hour has increased throughout the years thereafter, with rare interruptions or declines, and stood at something over 150 in 1922, at 215 in 1929, and reached a peak of almost 280 in 1941. The average annual rate of such increase in output per man-hour has been approximately 3 percent. Since 1941, however, the output per man-hour has remained almost stationary and in the last year for which such information was readily available stood at 275.

The reasons that this unit of output did not increase during the war period, the members of this audience will fully appreciate. In my opinion, it may be explained by the massing of employment under pressure conditions, including the recruiting of many untrained men and women, the latter being used to an unprecedented extent in the proportion to the total personnel thus engaged. I sincerely believe that this experience or performance during the war period can in no way be ascribed to any lack of patriotic devotion or effort.

In this connection, there should be appreciated another important aspect of the relation of labor to output and that is the almost incredible extent of the variations or ranges in individual skill and capacity found among workmen. Most executives responsible for the supervision of production agree as to these wide degrees of proficiency among their employees. It is believed that the following tabulation, expressed on an index basis and rating such variations in skills and capacity, represents a fair appraisal in this regard.

Percent of Normal Employment	Individual Skill and Capacity on an Index Basis
First 33	100
Second 33	75
Third 33	50

If employment is greatly increased beyond normal, let us say doubled or tripled, the factor of dilution in skill and capacity becomes even more pronounced. In my opinion, it is perhaps not too far from the fact to state that few of the workmen who are engaged to augment substantially a normal working personnel in a representative factory would reach the 50 percent effectiveness of the lower third of the normal complement of employees as cited above.

Scientific methods for measuring such skill through time and motion study, etc., together with the installation of fairly devised wage incentive systems, give some supporting evidence in this regard. It is not uncommon that under a wage incentive system the average output per man may be expected to increase from 20 to 25 percent and in individual cases to as high as 40 percent. This illustrates the truth that maximum output can not be attained until the latent energy and capacity of every employee is fully availed of and exerted.

Closely connected with the increase in productive capacity of this country and in the output per man-hour are the expenditures made by industrial companies both for betterments and improvements and expansion in actual capacities. The continuation of such expenditures is vitally important to the future in order that we shall attain the utmost in productive capacity and economy, not only for stable peacetime conditions but from your viewpoint regarding such capacity as an instrumentality of supplying the demands of any war which might eventuate in the future.

Statistics compiled by various government agencies show that such expenditures by industry, except in depression years, range from two to three billion dollars per year. The average of such expenditures for the period 1939 to 1945 was at the annual rate of two billion six hundred million dollars. It is gratifying to report to you that in the years 1946 and 1947 such expenditures amounted to five billion nine hundred ten thousand and seven billion two hundred ten thousand dollars, respectively.

Most of these expenditures have not increased the productive capacity of the country and were applied largely in replacements of older equipment for the purpose of reducing costs, etc.

It is, however, becoming an increasingly difficult problem for corporations to obtain such sums from earnings retained in the business and especially in view of the currently inadequate depreciation rates allowed by the United States Department of Internal Revenue, having in mind the cost of replacing today the machinery, equipment and other investments, and fixed assets which are consumed in our process of actual production.

In this connection I quote from a British technical magazine known as Forecast.

> "Capital investment is no theoretical concept, it is the bricks and mortar, the steel scaffording, the boilers, the furnaces, the presses and the castings, the mixers, the whole paraphernalia by which goods are made, and it is the roads and the railways and the ships by which they are transported from factory to consumer. The measure of capital investment in working condition is a measure of the country's productive capacity. Cut investment and you reduce in geometric progression the capacity to produce a given quantity of goods. The rate of capital investment is a measure of the country's prosperity; when capital investment falls off business activity does not merely fall by the same rate, it catapults to the bottom of a slump. When the rate of capital investment begins to increase it drags up business activity out of the pit of recession; it is the very heartbeat of economic activity.
>
> "To cut investment at this point is just about as wise as making an incision in the heart."

In any discussion of productive capacity the marked advances made in the increased productivity and versatility achieved in modern designs of practically all machinery and equipment must be given full consideration. This accomplishment is significant not only in its implications of potential capacity but for the manner in which it complicates actual measurement of current capacity because installations generally still comprise older units in operation which are not so productive as modern designs. In the case of any specific plant, therefore, the relative proportion of old to new equipment must be ascertained and evaluated.

As illustration of the marked advances made in the increased capacity of modern machinery and equipment, I remind you of the well-known contribution made by tungsten carbide, both as a cutting material and in drawing dies. In my lifetime I have witnessed the progression from carbon tool steels to high-speed tool steels and then to tungsten and tantalum carbides. In terms of weight of chips removed per hour, the carbide cutting steel tools are approximately fourteen times more productive than carbon tool steels and two-thirds more productive than the best high-speed steels available. Despite this fact, many plants continue in operation machine tools designed at the time carbon tool steels were the only ones available and many more which were not designed for the full effectiveness made possible by the carbides.

You are familiar with the long interval which elapsed between those changes in the design of machine tools which accommodated them to the increase in output made possible by highspeed steels. Fortunately, and under the stimulus of the carbide cutting materials, machine tool builders considerably abbreviated this interval in redesigning their equipment in order to use the full capacity of the carbide cutting materials.

Despite this fact, the Census made every five years by the American Machinist shows the following comparison of the percentage of machine tools ten years and older.

	Percent
As of 1 January 1925	44.4
1930	48.2
1935	66.7
1940	73.1
1945	38.0

It is gratifying that under the impetus of the war effort so substantial a gain has been made in the modernization of metal working shops in this country as that indicated by the favorable increase in the number of machine tools not older than ten years which are now installed in this country. It is equally gratifying to recognize the great increase in the number of machine tools now installed in this country. In the period from 1940 through 1945 almost one million machine tools were produced in this country of which number approximately 25 percent were exported under Lend-Lease or other governmental authority.

Those that have been retained in this country have increased the total number of machine tools now available for use from approximately 900,000 in 1940 to over 1,700,000 in 1945. In this connection it is pertinent also to advise that the modern machine tool with its refinements and improvements in design and operation is estimated to be 30 percent more productive than similar designs of 1939.

Another signal instance of vast improvement in rate of output as well as in quality is that of the continuous rolling mill for light plates, sheets, etc. This development, in my opinion, has been one of the most dramatic and important in the history of the steel industry and was commenced in 1924 when the first installation of its kind was made. Since that time, the capacity and number of such mills have increased to large proportions and have virtually supplanted the former methods by either hand or mechanized hand mills. The difference in cost of production gives some measure of the differences in rate of output. Such costs per ton on continuous mills as compared with hand mills, show a difference of at least 15 dollars and as much as 24 dollars per ton of sheet produced.

Modern rod mills operating at speeds almost twice that of older designs can now produce 46 tons per hour as compared with only 9 tons of older designs. Merchant bar mills show the same performance and in a 14-inch size in one installation of which I am informed showed an increase over the mill it had supplanted from 12,000 to 40,000 tons per month. In this connection you will be interested in the following statistics of wire rod mills and merchant bar mills showing the percentage of such mills which are ten years or older.

	Wire Mills	Merchant Bar Mills
Percentage 10 years or older	78	90

The importance of the layout of new equipment or the manner in which the flow of product proceeds has definite and direct influence on output or productive capacity. On the subject of layout or flow procedures alone I could presume fully on the time alloted to me but I must only mention its important bearing upon output or productive capacity and the fact that relocation and rearrangement will frequently vastly increase productive capacity.

During the war years we were retained by a concern engaged in the production of spirally wound paperboard protective covers for shells. With no sense of individual professional pride of performance I would like to quote from a letter from the president of that company as follows:

> "Mr. Blank did a masterful job for us and we followed his suggestions and recommendations to the letter. Specific proof of his help can be visualized when I tell you that before we engaged your Company our production processes required 324 employees per $100,000 of production, whereas within 60 days after we converted the plant following Mr. Blank's recommendations our costs showed that only 197 employees were being used per $100,000 of production. And the latter figure will come down to about 150 employees if and when we get stabilized releases and longer runs from the Army."

The factors above enumerated are indicative of the real problem of measuring or determining the productive capacity of this country either on an over-all basis or in a specific instance. That, together with the discussion of the imperative importance of an adequate supply of electrical energy, the productivity of labor, etc., have been submitted to you as a background against which to consider, perhaps, the more immediate and pratical aspects of the problem which comprise the subject of this address.

Fortunately many products and commodities are of such character that their output can be measured in reasonably comparable units, such as tons, barrels, gallons, yards, etc. Much of our basic production can be measured in terms of such physical units and hence, the productive capacity determined accordingly. Even in these instances, however, consideration must be given to intervening factors, such as bottlenecks, inadequate maintenance and other aspects of operating control which govern continuity of output.

At the outset, I trust you will agree with me that productive capacity is in essence an arbitrary measurement essentially empirical, almost theoretical in character. The actual rated capacity of any piece of equipment or series of installed units may be readily determined but its performance in day-to-day and month-to-month operation will vary widely from the theoretical indications of such ratings. As such, rated capacity is somewhat comparable to the mathematical concept of infinity, which is something approached but never reached.

As a consulting engineer engaged constantly in undertakings in which the determination of the relation of actual output to either theoretical capacity or what might be termed, effective capacity, compiling statistics and analyses make up almost our daily function.

Coming now to the practical necessity of dealing with all of these variables and arriving at a determination of productive capacity, we recommend strongly the use, where output can be expressed in terms of practically identical physical units as a measurement of productive capacity, the record of peak output as sustained for a period of one month. This we regard as an acceptable and defensible measurement of effective productive capacity. It is the method we employ where such determinations are required and it is the one adopted by the American Iron & Steel Institute in the establishment of the rated capacities of the various operating departments of all our steel companies as the same are compiled in the Directory published by that Institute.

The same procedure or method of determination applies in the important paper and paperboard industries and can be carried effectively into such other basic industries as petroleum refining, cement manufacture, coal mining, etc.

Frankly, this method is not novel and probably all of the members of this audience are thoroughly familiar with the procedure. I have no conceit that this utterance by me will bring to you anything not already known to you.

However, there are a number of other products and articles of commerce which do not lend themselves to this method of determination of productive capacity. I mention in this connection the aviation industry, both in its aircraft and engine divisions, the automotive industry and, in fact, pratically all of those industries which might be designated as assembly operations from fabricated parts or components. Admittedly in many of such cases there are units of output which can be subjected to the same method of determination of productive capacity; but, they are fraught with a far greater number of variables governing the vital flow of parts and components to final assembly so that it is unsafe to use this method without penetrating beyond the assembly line to the part and component fabricating departments, and, as well, the practice, policy and efficiency of part and component stores or generally the competence with which the inventory of such items is administered.

When the fabricating departments are considered, there is confronted the almost myriad number of different parts and components required for the assembly of the final product, dependent upon the method of identifying and counting them. Let us assume that the modern automobile has 5,000 parts or components. The problem entailed in the production or procurement of such parts and components is very real since many plants are

out of balance in their capacity to produce a well proportioned flow of such parts and components. This experience is so common that it makes up a very large proportion of the investigations, studies, and recommendations of the practice of an organization such as the one with which I am connected.

It is not an easy task to ascertain the lack of such balance or the manner in which it should be remedied. It involves the necessity of a complete bill of material, including every part and component and it would surprise you to know how many instances are encountered where such bills of material are not available. Even if the bills of material are available the next requirement is that of an operation sheet for every part or component. This operation sheet shows the raw material from which the part is fabricated, both as to its composition and the form and dimensions in which it is to be used.

It then proceeds in sequence to set forth each of the individual fabricating operations required to transform the raw material into the finished part or component, the machine tool or other equipment required for each individual operation, the jigs and fixtures similarly and the time required for the fabrication, allowing for set-up requirements, etc. Therefore, in order to determine whether a given assembly line, the peak monthly output of which can be readily measured or determined, is supported by adequate, well balanced fabricating facilities, it is necessary to compute the aggregate time requirements of the individual operations of each part or component and to relate this total to the available hours of each type of metal working equipment installed.

In the event that such a calculation shows a lack of balance there are various ways in which such deficiency can be corrected. One is the operation of additional shifts for those departments or major installations which are not adequate and the other is the one familiar to you, namely, that of subcontracting.

However, even if this calculation indicated a satisfactory balance of the working load it should be recognized that the control and direction of the productive operation has important bearing on the realization of the program thus theoretically computed.

Therefore, it becomes an essential part of any such study to examine carefully the methods of production control and planning which are employed in the given instance and the wisdom with which the lot sizes have been selected and applied with the viewpoint of maintaining fullest utilization of the fabricating equipment and at the same time an even and properly proportioned flow of the many parts and components into storage for final assembly.

One of the key indices of effectiveness in this regard is the record of lost time on each piece of fabricating equipment. Such record discloses relative over-all efficiency and sometimes also suggests simple remedies for improvement and betterment in output.

Once this procedure is followed and balance of effective output in the fabricating divisions is definitely established so that an assured flow in the supply of parts and components is certain, then, even in assembly industries producing one type or size of final product, the same basis can be used for measuring productive capacity as that recommended for the unit industries mentioned above and that would be on the basis of the record of peak output sustained for a period of one month.

However, in many instances the output of assembly lines comprise a number of different products either in type or size, involving different rates of output and hence, productive capacity. When multifarious products are thus assembled, the necessity of determining a common denominator or ratios of equivalents is, of course, manifest. Under such circumstances and in default of some better index, dollar values of the various products and the relativity in such amounts can serve. In this connection, personally, I prefer to utilize the cost of production in terms of dollars rather than sales value. Better than that, however, I strongly recommend the use of units comparable to those developed by time study, either as the basis for a wage incentive system or merely for control of production. Such units, usually expressed in terms of man, machine or production center hours or decimals thereof, can be employed usefully in determining aggregate productive potential. This can be done readily on any basis of the respective proportions which the different types or sizes of finished products may be made or required to be made.

In conclusion, I trust that I have made readily understandable the variety of elements and factors which enter into any computation of productive capacity and, as well, the various approaches which can be made to such a determination, dependent upon the products made and the methods and processes by which they are manufactured. I trust also that I have made equally understandable those aspects of this computation which are complicated by the variety in the capacity and efficiency of machinery and equipment of different ages or vintages of origin and the manner in which adjustment can be made in the computations for any particular case.

It has been a pleasure to appear before you; I welcome the opportunity and honor of so doing. It is my hope that in some small way my comments and suggestions may prove to be helpful to all of you in your present and any future responsibilities which you may assume, especially having in mind the critical urgency of your activities both now and in the event of war.

COLONEL CRANE: My question concerns the problem of determining the capacity of an item which we need in the Armed Forces but which is not currently manufactured by industry. Have you any suggestions as to how to approach that problem?

MR. ARMSTRONG: I am afraid I have. I do not know how welcome they will be to the Army and Navy.

I happened to serve as chairman of the Engineering Advisory Committee of the Division of Contract Distribution of the Office of Production Management. The thing that staggered me then was the problem of an established commercial venture taking on a new product. That was understandable because, although some of the designs had not been fixed, they were anxious to get the products out. But there was no bill of material, there were no operating sheets, and all of that work had to be done before you could possibly translate the product into a plant where it might be produced.

It is true that the Division had some very interesting methods of measuring capacity and deploying capacity for the war effort. I feel, however, that if the Army and the Navy would go beyond the mere function and design stage down to the point of translating a piece of materiel into a working program for industry, not only would effective output be considerably accelerated, but they would also have a rather definite conception of what capacity would be required in order to meet a given program of procurement. That is merely my opinion, Colonel Crane, but I really believe that it would be highly desirable to do that. You would not believe the amount of leg-work that had to go on in search of what should be done, how a thing should be done, and, if you found that out, where you could go to have it done. That, I do hope, is a gap we won't be confronted with again.

QUESTION: Following that up, sir, could you give us any idea of the number of man-hours required to set out process sheets, and so forth, as compared with the ordinary design drawing?

MR. ARMSTRONG: Do you mean the amount of work involved in translating the item from the blueprint to the operating sheet?

QUESTIONER: Yes.

MR. ARMSTRONG: It is considerable. It is a big job, especially with the war mechanisms of today as complicated as they are. I would say it would be at least equal to, and might run to two or three times as much as, the number of man-hours involved in the design.

I don't have to tell you gentlemen this, but a man can be a "Rube Goldberg" and make a design without any difficulty; and there is no responsibility until it gets down to the practical business of producing it.

As a matter of fact, some establishments today have in their design departments a section they call the "Rube Goldberg" department. They say, "We want to do this a different way. You draw something." They draw something, and then it goes to the more practical commercial fellow who knows what they have to sell industry on. He eliminates most of them and changes them, and so forth. I think that to do the job adequately a ratio of two or three to one would not be excessive.

I don't know whether you would agree with that.

QUESTIONER: Yes, sir. That is why I asked the question. We do happen to do it on some products, such as guns. When you see the size of the paper that is required to get out those operating manuals, you find it is colossal.

MR. ARMSTRONG: I know it.

QUESTION: Does that indicate a lack of proper training of engineers in design work and that the courses in our universities should be modernized for mass-production design?

MR. ARMSTRONG: You touch upon something that is a little delicate to answer, and that concerns the general effectiveness of any academic routine in teaching a practical subject. I regret that there are no such things as exchange fellowships whereby faculty members could be put into industry and then returned to their academic teaching. Frankly, I believe that in most technical schools today there is a definite gap between theory and reality which has to be bridged. Again, that is purely my opinion.

Now, some institutions are moving to correct that. And it is not only in the administrative engineering course where that is done. It happens wherever there is a broad-minded head of a department who realizes that he is teaching these boys a lot of stuff that they are cramming into their heads and that when they go out into life, they won't know what to do with it. He is apt to bring in men from the outside to lecture to the boys very much as you gentlemen do. Sometimes you catch something good, sometimes you catch something just so good, and so on down the line, as you well know.

I do believe there is a definite weakness in that respect in our educational institutions. Yet it is such a simple procedure; there is nothing profound about it at all.

QUESTION: Following that along a little further, if this condition is prevalent in industry, as we know it to be, doesn't it also indicate a breakdown of management in proper correlation of the various departments?

MR. ARMSTRONG: That is a good question. Of course, there are all kinds of management. There is the top kind of management that exists in the large company where it can afford to hire specialized brains, and there is the kind of management one finds down in the lower echelons where the budget simply will not permit that therefore, they have to rely on something that is not so good.

I think, generally speaking, that the larger companies demonstrated in the war an extraordinary versatility and adequacy in providing that kind of service. I might just mention General Motors and Chrysler--and there are others--to show that there is absolutely no lack there. When you come down to the other places--and they make up the major part of our productive capacity--you find they need help; there it is a weakness of management, I think, not so much in understanding as in pure dollars and cents. How can they afford to get it!

I know no answer to that. It is a very real problem. It is something Mr. Harriman is tussling with now--how to help smaller business. Despite all the testimony on the "Hill" and despite all the men who can represent the need very greatly, I have not found anybody who is ready to put forth the money to buy the answer.

QUESTION: Mr. Armstrong, getting back to these process sheets and the suggestion that you make of the Army preparing them, is it not true that the sequence of operations that is stated on a process sheet depends on the type of machinery in the plant?

MR. ARMSTRONG: Very definitely.

QUESTIONER: And if the Army made a process sheet and took it to some plant for which the process sheet was not specifically made, it would have no value; isn't that right?

MR. ARMSTRONG: You are quite right. That is a very sound question. In my opinion, the Army, in making up these process sheets, should show, in such instances, the alternative equipment which might be used. It is perfectly feasible to do that, although, admittedly, it somewhat multiplies the chore; but I believe firmly that it would greatly facilitate the effort if and when we are called upon to make it again.

MR. MASSELMAN: Mr. Armstrong, you mentioned the need for capital investment to sustain an increase in industrial output. It has been pretty well established that in this country since 1929 we have had very little, if any, net capital formation. Can you tell us what, in your opinion, may be the long-range effects of that long hiatus we have had in this period of non-capital formation?

MR. ARMSTRONG: I shall express it quantitatively by stating that various estimates have been made as to the amount of the arrearage, so to speak, which has accumulated and which should be spent in order to make us fully effective, meaning by that, taking advantage of the latest developments in mechanized technology. Those estimates range all the way from fifty to seventy-five billion dollars. That embraces not only industry but transportation, public utilities, communications--in fact, all phases of this complex of output effort.

I have thought a good deal about that. It is a towering sum. I am hesitant to express my opinion here in a government agency; but I can tell you that before the war and since, I have represented clients before the Department of Internal Revenue, and I have been appalled by the attitude of the Department with respect to allowances for depreciation. The whole trend over the ten-year period prior to the onset of the war in 1941 was constantly to reduce the rate of depreciation--constantly to reduce it--and hew close to the line of straight-line depreciation. That was a very discouraging factor at that time.

As to the situation today, let me give you an illustration. A client of mine in the paper business has a daily capacity of 2,200 tons. That investment stands on his books on a net basis of 38 million dollars. He is increasing his capacity 15 percent, and the cost of that 15 percent is going to exceed 38 million dollars. Now, you hesitate, if you are a prudent executive, to commit yourself to capital expenditures when you just do not know what the ultimate value of the dollar is going to be. There are those who say that in 1950 it will be 75 cents; there are others who say in 1950 it will be 25 cents. And they argue with equal cogency on a thoroughly conjectural topic.

Actually, I think industry, in its blind way, is working pretty well. Its commitments for 1948 are quite substantial. They are two or three times what they were in the period prior to the war, so we are making progress; but I think the progress has to be stimulated by a recognition that capital of that character should get something comparable to the accelerated amortization for war facilities. I firmly believe that, great as we are as an industrial, productive power, we are not anywhere near where we would be if we were able to translate what I am talking about into actual performance and accomplishment.

QUESTION: Do you think the Armed Forces should make out their own production sheets or that, after they have completed the design, they should turn that over to business and have business make up the production sheets?

MR. ARMSTRONG: I think business would be willing to do it, but I think business would have to be compensated for doing it. Any board is limited, in dealing with its responsibilities to stockholders, as to how far it can go in making services available to the Government for nothing. I think

industry would be delighted to do it. However, my own opinion is that the officers in our Armed Forces would be much better men if they were exposed to the necessity of doing it. I hope you will pardon that observation. I really believe it.

COLONEL GODARD: Coming back to a point you mentioned about design, the "Rube Goldberg" angle of it, I have observed that the designer often will sit in a little ivory tower all by himself working on his design. After its completion, he unlocks the door and shoves the design out. Then everybody has a very difficult time trying to straighten it out. It looked fine to the designer, but producing it is another matter.

I have contended for a long while, sir, that we could get better results by putting good shop men, master mechanics and shop foremen, together with the designer into a combined department and sort of riding herd over these design people. Do you think industry will ever get around to the point of having all the men concerned sit around the same table with the designer and work the thing out together?

MR. ARMSTRONG: There are not many instances of that type of liaison. One forward-looking company that has established this "Rube Goldberg" department has three design departments: the "Goldberg," one having sound, practical technical men, and one having commercial men who know what they have to sell industry. I know of no instance where practical, manufacturing fellows, who have to produce this design, are really brought in to say, "Let's do it this way." It is a thing industry could very profitably do, and all are really learning very rapidly.

Of course, one of the problems in that connection is the fact that there is more and more dependence in industry today upon streamlining and so-called modern design, the "new look", and it goes outside for these professional designers, some of whom are very brilliant and resourceful but not many of whom are responsible for manufacturing their designs. It takes much screening and much editing to bring one of those designs down to a feasible basis of manufacture.

Your point is a good one. I do not think that is done enough. I am sorry I did not think of it to put it in my address.

QUESTION: The Armed Forces are very conscious of research and development and the need for spending money in that direction, but it seems to me that we are not conscious of the need for translating the results of that research and development into a realization of the full potential of our industry to produce. I wonder if our Armed Forces could not spend money to really good advantage in adapting our new development to industrial design.

MR. ARMSTRONG: Can I really be frank?

COLONEL CRANE: Yes.

MR. ARMSTRONG: You know, gentlemen, I live a life of confidence. There are a good many fellows in industry, and especially in aviation, who have said, "If only that damned Armed Forces bunch stayed out of this development, we could go places." So when you raise that question as to what the Army might do or the Armed Forces might do in working out a better relationship to accelerate and to improve the results of research and development, you get again into the equivalent of that "town and gown" and college life. It takes a real diplomat in behalf of the Armed Forces to represent intelligently and convincingly to industry that this is a good idea. It is very easy to generalize. There are many exceptions to everything you say. But I would say, by and large, since VJ-day the country has been more concerned with getting the goods out and curing its shortages than with development and design. So there has been somewhat of an arrest of progress in that direction. Industry is waiting for this condition of excess demand to subside before it comes out with another shot in the arm to tease the trade.

In answer to your question, I think it is an excellent plan. In other words, I do not see why the design of war-making equipment should be exclusively within the province of the Armed Forces, admitting they know how to operate it beautifully and that they are the only ones that can be given that responsibility. But I do believe that industry could be of tremendous help in shaping those designs. There are many new things coming out, new materials, new experience with the materials, new methods of treating them, and so forth. In answer to your question, I can only say I think it would be wonderful.

COLONEL CRANE: Mr. Armstrong, we are certainly indebted to you for a most interesting and instructive discussion.

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