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MANAGEMENT CONTROLS IN INDUSTRY

26 February 1953

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COLONEL CAVE: There are some subjects which it is a double delight to introduce to this class because not only do they pertain to things we are trying to get across in the Production Course but they also give us something we can take away and use actively, I think--in the different departments--when we leave here.

As you know, because of his excellent presentation two years ago on the subject of "Quality Control," in which he is a noted expert, we asked you to read Dr. Juran's lecture of two years ago. But in asking Dr. Juran to lecture to us today, he said that he would like to get back to the basic philosophy underlying all controls and, of course, in Production we are interested in more than quality controls; there are inventory controls and others. So it is an especial pleasure for me to be able to introduce to you today Dr. J. M. Juran who will talk to us on this subject of controls.

DR. JURAN: Thanks very much, Colonel Cave. Gentlemen, what I am going to discuss with you is the universal character of controls. I am going to put before you the thesis that there are universal rules or principles for control and that through the exercise of those principles you can control anything. In order to demonstrate that, let me ask you to refer to the sheets that have been handed out to you. I will also put them on the screen for easy observation. I will confine my remarks to Industrial Controls.

Chart 1, following page.--The managing of anything involves a continuing cycle of planning what to do, doing it, and then observing what is being done so as to revise the plan. That is an oversimplification of that cycle, but there is no debate that such a cycle is present. The control phase, seeing to it that the plan is carried out, involves the series of steps listed on this chart. These steps, I assert, are necessary and sufficient to control anything.

The first of those steps is the definition of "control points." I mean by control points the choice of what are the important elements of the plan; what are the things that we need to regulate. Until we have defined the control points, we have not decided what part of the plan we are going to insure will be carried out.

The control point may be time, that is the regulation of the timetable; it may be money, some budgetary regulation; it may be some specification as in the case of quality regulation, and so forth. I

CHART 1

THE FUNDAMENTALS OF CONTROL

Management involves a continuing sequence of:

What management does	Often called
Planning what to do	Planning
Doing it	Operating
Seeing that it is done per plan	Controlling

Controlling (seeing that work is performed per plan) includes the following steps which are fundamental to controlling anything:

1. Selection of control points
2. Definition of units of measure
3. A systematic means for measuring and summarizing actual performance

These steps are essential to measurement of actual performance.

4. Selection of standards of performance
5. Interpretation of the difference between actual performance and standard
6. Decision on what action to take
7. Action to comply with the decision

will elaborate on that shortly. But it is the first step, and it gives us the nucleus around which the control is going to take place.

The second stop is the definition of a unit of measure. In the absence of a unit of measure, we talk in adjectives, in words that do not have the same meaning to the other fellow as they do to ourselves. Therefore we are unable to convey our plan to him in the first instance and give him the means to measure performance in the second place.

The third step is a systematic means for measuring what is taking place, for utilizing this unit of measure to express what is taking place with respect to the control point. The word "systematic" is in there with malice aforethought. Organizationally, it means that it must be somebody's job to do the measuring and to bring the resulting data to those who are going to be responsible for carrying out the plan.

Those first three things together--the selection of control points, the unit of measure, and the systematic means for measuring--constitute our way of discovering what is taking place, what are the facts. They do not tell us what should take place. That is the standard of the performance. So a fourth essential of control is the establishment of a standard of performance, the schedule, the budget, the quota, by whatever name it goes.

Fifth, there is the problem of interpreting the difference between actual performance and standard. It is at this point we bring into play what we have come to call the statistical methods of analysis. This analysis involves not only the understanding of whether the difference is significant or not; it is also the understanding of what is the relationship between cause and effect in case of a difference and still other devices of analysis.

It is in this realm that a very considerable body of learning has been developed over the last decade, or at least has been applied much more intensivley. This body of learning is, by some, called "Operations Research"; by others, "Statistical Quality Control." There are other terms used to describe this learning in still other fields. In all cases they are concerned with the statistical analysis of what is taking place in the light of what ought to take place.

The remaining two steps which are fundamental to controlling anything are, sixth, the plan of what should be done in the light of the analysis and, seventh, the manner of taking action, both being very diverse and complicated.

Chart 2, following page.--I have singled out, just for examples several problems of control in industry: The control of sales volume;

CHART 2

The elements of control	Names of these elements commonly encountered in control of			
	Sales volume	Production	Quality	Cost
1. Control points	Product line, region, district, salesman	Orders, promises, units	Quality characteristics, i.e., dimensions, weights, etc.	Accounts, categories, i.e., direct labor, materials, process, etc.
2. Units of measure	Dollars, units	Units, weights, time	Inches, ounces, ohms, etc.	Dollars per unit, hours per unit, etc.
3. Measurement	Sales accounting	Production control	Inspection, test, gaging, examining	Cost accounting
4. Standards of performance	Quotas, targets	Schedules	Specifications, samples	Standard costs, bogeys, estimates
5. Differences between actual and standard	Variance, quota failures	Shortages, backlog, promises not met	Defects	Variance, deficit
6. Decisions on what action to take	Incentives, territorial realignment, etc.	Expediting, schedule revision, etc.	Rejection, repair waiver, defect prevention	Cost reduction, work simplification etc.

7. Action through tables of delegation, organization structure, systems, procedures, routines, programs.

control of production. When you hear an industrialist using the term "production control," he is talking about the timetable--quality control and cost control. Of course, we can go on--control of expense, control of inventory; and so on and on. All of those things we have to regulate, including control of morale. Each one of these vertical columns of chart 2 is an example of a problem of control in industry.

The horizontal lines are the same as chart 1. Choice of control points is first. As you can see--let us start from right to left--in the case of cost control we work up accounts and categories of cost and those become the things we watch--the cost of this particular operation, cost per pound, cost per piece, cost per hour. There are various ways of expressing that as we can see by dropping down one line there to the "Units of Measure."

Coming back to the column next to it on the left, we have the choice of control points in the case of control of quality. There we get into the various quality characteristics--the length, the weight, the chemical purity, and so on. All of those qualities are, of course, measured in terms of scientific units of measure, for the most part. In those cases where we have not developed units of measure, such as visual requirements of one kind of another, we have our troubles, because the unit of measure is an essential thing.

I might at this point give you a universal rule with respect to choice of control points. No matter with what we are dealing, it is always a fact that a small percentage of the number of items we are trying to control involves a high percentage of the importance of what we are trying to control.

Take a case of inventory control, a real problem we have in industry. Suppose there are 10,000 different items in the inventory. If you list those items in the order of value, putting the most valuable ones at the top, it is inevitable that something like 5 to 10 percent of the items will account for about three-fourths of the total inventory. In one study made by one of the companies--if I remember the figures correctly--7 percent of the items in the inventory accounted for 87 percent of the value.

At the other end of the distribution, the last three-fourths of the items will account for only a few percent of the value. In between are the items where there is a close balance as to the cost of control versus the value of controls.

In that first group, where the value per item is very high, there is no question about the usefulness of the cost of control. At the other extreme where the value per item is very low, the cost of control is not worth it. The cure becomes worse than the disease.

To control the inventory of those high value items, we make a list of them. For each one we establish a minimum order point, a maximum order point, and an economic ordering lot size. We provide a table of delegation such that it takes some pretty important signatures to act with respect to those high value items. The amount of effort involved is not great because it deals with only a few percent of the items.

In the other extreme--the 75 percent of the item that involve only a few percent of the value of the inventory--in the case of the company I mentioned, they found it most useful to order those things only once a year. In this way they deliberately have much more on hand than they need in order to avoid some trivial part becoming a shortage. But the effect on the over-all inventory is small. On the other hand they save greatly in paper work. For many of those small value items, the cost of issuing a purchase order exceeds the value of the goods. The savings involved in issuing one purchase order each year instead of 12 more than paid for any added cost to carry the inventory.

The same principle holds in quality control. Our losses due to defects or failures are likewise concentrated in a small percentage of items. If we have 10,000 different quality characteristics in our specifications, the first several percent of the 10,000 items accounts for three-fourths of our quality troubles. The same thing holds for personnel problems. You may have 10,000 men, but only a few percent give most of the headaches; and so on. These instances are examples of the universal rule with respect to choice of control points. If we ignore this principle, we sometimes develop a control system that is too ponderous. It falls of its own weight if we try to apply it to every single item instead of applying it to only a small minority of the items which could usefully be controlled in that way.

Now a word about units of measure. Let me recite an instance to indicate the way in which units of measure, when developed, can open up a field of know-how that is far beyond anything that has existed.

There is an optical company which had quite a problem with scratches on lenses. That is a pretty important disease in that industry. It may sound to those not in the optical business as kind of a silly thing to worry about, but it is a matter of life or death in that industry.

The road-block to progress was in the fact that they were unable to measure what they were doing. They were unable to compare processes, methods, costs. For example, ordinarily if we want to compare two processes, we take a bunch of parts and divide them. Half go through process A and half through process B. Then we can determine which process gives the best results, if we can measure the results. Unless there is a way of measuring, we are unable to choose between the processes.

In this company they had undergone a change in specification for scratches. They were worried that the factory might become worse and worse with respect to these scratches. So they decided to set up a measure of the scratch content of the lenses. To do that they had to go through a tedious procedure. They made up some plates which had scratches of known width on them, very carefully made. Then, every week, an independent inspector would look at 500 lenses chosen to represent the cross section of the manufactured product. He measured the width and length of all the scratches on those 500 lenses. It was a tedius thing, at least for that inspector. By having the length and width of the scratches, they determined the scratched or damaged area. By relating the damaged area to the total area, they had an index, a unit of measure.

They charted that index week after week and, if I drop off some zero's, the resulting level was around 12. Remember now they had made this up to watch whether the factory was going to get worse as to scratches. They didn't want the factory to get worse just because their specifications had changed.

They found that in some weeks the 500 lens samples were much worse than 12. These weekly fluctuations that didn't seem logical, because so far as they knew, the process didn't change that much. On investigating why these lenses were so much worse in some weeks than in others, they made the astonishing discovery that during the weeks when the index was high, the sample contained a high proportion of lenses that had gone through a certain operation X.

From there it was only another step to consider: Suppose we measure the scratch content of lenses which have 100 percent gone through operation X. That was found to be about 36, whereas the scratch index of lenses that had not gone through operation X at all was found to be only about 4. So, as a by-product, you might say, of developing a unit of measure, they found what was not only the main cause of the scratches, they found virtually the sole cause of the scratches.

They went a step further and examined the production process itself by "looking in" every quarter of an hour at the polishing of the lenses. They made the equally astonishing discovery that less than half the total production time was required to get the lenses up to their technical perfection of curvature and smoothness, that the remaining time was to take out scratches which needn't have been there in the first place. They have since taken some long steps toward mechanizing what has always been an operation requiring a great deal of cut and try.

I cite that as an example of the far-reaching effects of establishing a unit of measure where none has existed before. It sometimes takes a lot of effort to do that. But the new knowledge which emerges enables the people to make a breach in what has been a former barrier to progress.

They break through that barrier and then are able to make much new progress.

The word "measurement" on the left-hand side means the need for a systematic method of measurement, the designation of some individual or some group to do the measuring; unless someone is so designated, there will be no regular and independent source of information. We have measuring groups like that in industry as I am sure you have in the military establishment. The names of these groups are such as: Cost Accounting Department, Inspection Department, Production Control, Sales Accounting Department. In their respective jobs, they have among other things, the duty of making these measurements, of taking the data, and preparing reports of what is taking place currently.

Now if we are going to make use of the information of what is the current level of performance, we must have something against which we can compare that. Somebody says, "The inventory is a half million dollars." The first response of an executive is going to be, "Is that good or bad?" because until it is compared with a standard of what it ought to be, there is no way of appraising whether it is good or bad.

Those standards come to us in three different ways. The most common is past performance. We compare ourselves with the past and thereby we see whether we are getting better or worse. That is not a particularly good standard because we don't really have any right to presuppose that what has been done in the past is a sound level of performance. But in the absence of anything better we should use the past.

A second standard of performance is what we call the engineering standard. For example, for material usage we can compute in engineering terms what should be done, the amount of material needed to arrive at a particular result. We have some degree of the measure of that in the case of the utilization of labor, using labor in the sense of services of human beings. It is the same with facilities. Where we can work engineering measures, they are very useful standards.

The third standard we have is what we call market standard in which we compare ourselves with somebody else. We do that, for instance, in the case of safety. The unit of measure is accidents per million man-hours of exposure. We can compare, for example, the accident rate in our foundry with the rate for foundries generally, as reported to the National Safety Council. Or our absentee rate can be compared with the Bureau of Labor Statistics data; or our wage rate can be compared with the community rate in wages. Those are market standards.

Notice how each of these fields of endeavor has developed its own lingo. The salesman talks about quotas; the production control man talks about schedules; the inspector talks about specifications the accountant talks about standard costs. One of the evidences of a universal principle

is the presence, in all of these diverse fields, of a word which has the same meaning though especially applied to the particular field.

In the case of the interpretation of the differences between actual and standard, we really have several steps to go through. The first question is whether the difference that we observe is a significant difference--the test of significance, as we call it. We know that in the case of budgetary control we don't spend exactly the same amount every month. This month we ordered a supply of something that will last four months. Therefore, we will have a bulge as to that item of expense. For some other item there might be no expense for a year. That mixture of some expenses which are high one month and others which are low for that month, gives us a composite expense that also might be high or low in relation to the expected level. The first question is whether the difference between actual expense and budget is just the luck of the draw for that month or whether the amount is so great that it couldn't have happened just by the luck of the draw, and therefore must reflect a real change in level of expenditure.

Now we can compute by mathematical means which is which. Generally speaking, operating executives are not quite ready for mathematical tests of significance. They adopt a rule of thumb. If the expense is not 5 percent more or less than the expected level, then there is no need to worry. They allow a "tolerance." If the amount by which the actual performance differs from standard is greater than can be accounted for just by accident, then of course you have the question of what new factor has come in. What is the relationship between cause and effect? That sometimes gets to be very involved. That may involve the assignment of personnel especially for the purpose of discovering the relationship between cause and effect.

Let's go back for a minute to the scratches on the lenses. That investigation could not have been conducted by the line officials. They didn't have time, because they had a day-by-day treadmill to keep going. They did not have the mobility that was required, because they had to stay in their departments to take care of things there, whereas these causes for scratches had to be traced in a whole variety of departments. And the line people didn't have more than the very rudimentary skill of how to collect data and how to evaluate the data after they had it. So if the investigation was to be made, it required some separate individual who had time, and the mobility and skill to do it.

We have in industry a good deal of a road-block because not all of our managers realize that, for conducting studies of that kind, it takes somebody who is not on the day-to-day treadmill. That is a universal problem in management then to find out whether the day-to-day supervision is able to solve a problem or whether it takes a separate category of people.

I would offer you this working rule, that the day-to-day supervision is able to take care of some dramatic change in the level from the status quo. Consider a job which is going along at a certain percentage of yield and suddenly everything goes kaput and that yield becomes zero. That problem can be solved by the day-to-day supervision. Whatever happened there came along so suddenly and the timetable can be reconstructed so well that they can dive in and fix it. So by and large the day-to-day foremen are able to restore a status quo when something like that happens. But the line supervisor is not able to establish the cause of a continuing 80 percent yield and how to get up to a 98 percent yield. It takes separate personnel to diagnose that and come up with the facts.

Now the planning of what to do, based on this analysis, is so varied and gets into so many different kinds of plans that I am not going to discuss that except as it may come up during the question period. The same thing is true with respect to the action. Rather I would talk about the action in terms of the remaining diagram, which is what I will put before you now.

Chart 3, following page.--This series of steps required for control to my mind is not simply restricted to control in industry. We have the same thing so far as control in engineering is concerned--the servo-mechanism principle. I believe it applies also to control in the biological being, the biological organism. On this chart I have used the engineering lingo. One of the previous lecturers has gone over some of these things, but I am going to tie this in because it fits so well with industrial control and, if anything, enlarges the universal character or concept.

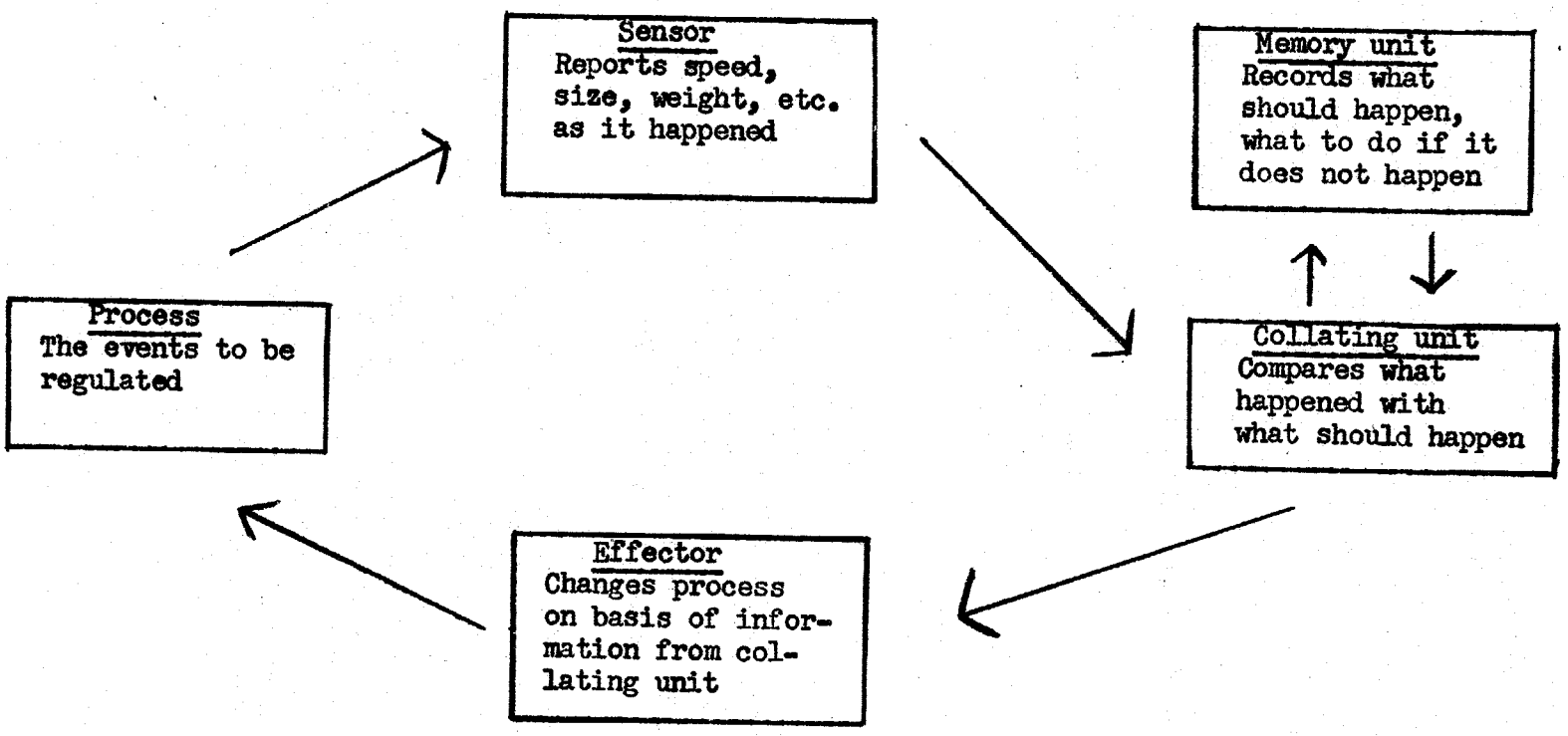
The servo-mechanism principle is a forbidding term. What it involves isn't at all forbidding. Take the simple example of the thermostat and the way in which it evolved. Let us trace the process we went through before the days of the thermostat if one of us felt uncomfortably warm or uncomfortably cold.

We have a sense of comfort, a kind of standard comfort which is pretty hard to put down in words, but it is there and not quite the same for all of us. It becomes cold. Our sense organs in our skin and body tell us it is cold beyond our standard of comfort. Based on that we decide on a plan of action. We put another log in the fireplace or we go down and put some coal in the furnace. We are setting into motion a train of events which is going to raise the temperature, and which in turn is going to be sensed by us. That is the pedestrian process for regulating temperatures to suit ourselves.

We have come quite a ways from that--instead of using our skin and the rest of our sensory organs to determine whether it is cold or not, we put up a thermometer. We can read it and when the temperature

CHART 3

THE SERVO-MECHANISM PRINCIPLE APPLIED TO MANAGEMENT PROBLEMS



Process	Sensor	Memory unit	Collating unit	Effector
Expenditures	Accounting of expenses	Budget	Budget office	Executives
Production Control	Rate of deliveries	Schedule	Production planning and control office	Supervisors, schedulers
Quality Control	Inspection of product	Specifications	Quality control	Expeditors Supervisors, operators
Sales control	Accounting of sales	Quotas	Sales control	Sales executives

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goes below a certain point we can go and act on the furnace. But we can go a step further and connect the thermometer to the furnace itself. Then we have to build into the instrument a standard which is the tolerance of cold for us. When the thermometer reads a temperature below that standard, something is triggered into action. That is known as "closing the circuit." The furnace is started and the temperature begins to go up. When the temperature goes up, the same instrument continues to measure and shuts the furnace off at the appropriate amount above standard. The servo-mechanism for keeping some ship on course and for turning machinery on and off goes through the same cycle. Some of the applications require pretty involved engineering but the principle is just as simple. One of the first uses of the servo-mechanism was the flyball governor for steam engines.

Let us just look at the diagram. We start over on the left with the process, the events we are trying to regulate. We tap into there some sensory device, the thermometer, the measure of percentage defective, whatever you wish. That sensory device is special to some one control point such as speed, weight, and so on. The unit of measure is built into the sensory device and it can give us information about that control point in terms of that unit of measure.

So the sensor is what gives the facts, things as they are. That information has to be compared with a standard and that standard is built into what the engineer calls the "memory unit." And he has a "collating unit," so-called, which compares what is reported by the sensory device with the standard. That decides whether the thermostat, and so on, should go into action. Having then a decision by the collating unit that something should swing into action, through mechanical or electrical or other means, action is brought about through what we call the effector mechanism.

We use that same term in biology, the effector organisms as distinguished from the sensory organism. That effector mechanism proceeds to operate on the process; the process proceeds to change; the sensor measures the change, and that is the way the thing goes over and over.

I have listed down below the names of the process so far as industrial control is concerned--expenditures, production, quality, sales. Those are the things we are trying to regulate. We have special names for the sensory unit, the memory unit, and the standards. The effector has many varieties. It is operated through reports, through tables of delegations and the like. I can explore that with you and I am sure you are familiar with that, because the bigger the operation you are trying to regulate, the more is the need for developing these formalized methods of control.

The final point I might make in these formal comments to you would deal with the problem of securing action on the basis of selfcontrol as distinguished from imposed control through the intervention of a higher

executive. To my mind the problem of industrial control is in the nature of a tool for the aid of executives. I mean that literally--a tool for the aid of executives. It is not possible for an executive to supervise personally all the operations that take place, to see all the facts, to know what the standards ought to be. He has to have aids. The control tools are in the nature of a vital aid for the executive in achieving these controls.

Moreover, with all the information he might get, he may find that the cost of this particular apparatus is so much and the standard is so much; therefore, there is too much difference. Then he can get after the manager to take action about it.

Getting action is a complicated thing. So far as possible, action should be self-impelled rather than requiring the intervention of this executive. The more self-control that you can have, obviously the less of that kind of supervision you need.

It goes a step further. I think you talked about that during this series. The more that you can build into the self-control of the establishment the recognition of what ought to take place and what did take place, the more will be the action which takes place at the lower level and the more time there is available for the top people to concern themselves with the broad problems of perspective. The top people will have more time for broad planning and will need to spend less time beating out fires in day-to-day fashion. I don't know of anything that is worse.

Self-control is an effort to make the bulk of problems soluble by the people down the line. There are always going to be instances where they have to come up the line for aid and advice. But the more things that can be worked out at the bottom of the organization, the more aid it is possible for the man at the top to give in the complicated cases.

Industrial operation is a perfectly bewildering problem of control. There are so many things that we are trying to do. As to all of those things, we should have discussions in advance of what should take place and what is the standard. We should try to measure then what does take place. Where what does take place is in accordance with the plan, we leave well enough alone. Instead we devote our time to those instances in which the plan is not being met. Moreover, in the case of securing action, we try--some places we don't succeed, I will admit--to delegate to the lower levels the necessary authority to put the actual performance back on the track in relation to the planned performance. In this way we use the time of the higher executives for exceptional cases, the vital cases, and of course the planning of new and changed major activities.

I will close my remarks and leave it to you to develop, during the discussion period, the facets of this which I should have covered but didn't.

Thank you very much.

QUESTION: How do you think we should go about attempting to control such an organization as the Department of Defense so as to satisfy a lot of people--what would you measure? How would you measure it?

DR. JURAN: I am not going to duck that. The starting point is, what do you want to control? Now we have that same problem. If you bring together the officials of a company and say, "Look, we want to put in a means of control that will allow most of the problems to be solved down below and allow only major things to come up here. What are the things that you really want to come to you?" They can't tell you. Usually they haven't thought of it in those terms.

But there are ways of working it out. One way is to single out somebody who knows his way around the place and who also has some concept of what we have been talking about here this morning, the nature of control. Let him make the round of the different officials in the area where you want to try to work out the problem. Have him visit the different executives and officials. He has primed himself in advance, so he has some idea of the likely list of control points. He doesn't know the exact items nor does he know the priorities. He doesn't know what the final list will be.

He makes the rounds of the people to get their thinking on control points. Having made the rounds, he tabulates the information. If he has seen 30 people, then some control points will have been listed by 20 or 25 of those people and those control points are certainly going to be on the final list. Also every man has one or two things that he rides as a hobby. He may be the only one interested in that. But subsequently, if he is in a meeting with his peers, he is a lot less apt to hold out for it if he is the only one who wants it.

So when the man has made the rounds, he can go over the list and say, "Here are the things which are regarded as important. Here are the numbers. This number of people regards this as important." Then he can bring the group together and the agenda for that meeting is the result of that go-around. Then the people can agree on what are the things they consider vital control points.

To go a step further--this, as they say in some places, will slay you--there is not a person in this room who wouldn't subscribe to the idea that it is a lot easier to start a new set of information of some kind than it is to get rid of an old one. Sometimes the barnacles represented by the old ones get to be pretty formidable and quite a drag on the operation. The reason for that is in what the lawyers call "burden of proof." The burden of proof is properly on the person who advocates change.

Take as an example a report. There are 16 different copies of it. Somebody is going to try to get rid of it. He makes the rounds, visits all the people on this list to receive copies in order to see if he can get a unanimous vote to get rid of it. Two on the list are dead and gone. Of the other 14, the secretaries get those things; they pile up and they are thrown away. One man says, "I don't really use it, but you know a couple of years ago something came up and I did need it then."

How do you deal with that? Make the kind of go-around that I have mentioned of having a professional tour by some individual who has both the theory of control and practical knowledge of the operations. Thereby he is able to piece together an agenda from which the group can come up with group solution. You have then a list of what they have agreed on. Then the burden of proof shifts so that whatever is not on that list is suspect as being illegitimate. In other words the fellow who want to keep something not on the agreed-upon list now has to prove he needs it. So it is a way of combing out all the old stuff as well as bringing in the new.

QUESTION: Dr. Juran, over the years the military services have evolved as system of inspections that is quite well developed. In the Army I think it is called the Inspector General's Office; the Air Force calls it the Air Inspector; I don't know what the Navy calls it. It is a very well-developed staff activity that reports directly to the commander and is more or less charged with reporting to him on how his directives have been carried out by his organization. I don't doubt that there is a similar type of structure in industrial organization. I have often wondered why that hasn't been gone into more. In your presentation, it seems your inspection control is broken up into smaller particles. Would you comment on that?

DR. JURAN: I would say there is a lot more of that than is evident on the surface. In that connection you bring up a problem that bothers all of us, which is: Do we dare to have any official--commander in your case--report on his own performance? That is a touchy problem. If we transmit information through a series of echelons, do we get so much coloration that the final result is no longer in accordance with the facts? If you try to set up independent reporting that will by-pass those commanders, the result is we may end up with two sets of information, two separate groups, two reports. The reports never agree and we fight over which report is right.

There is a way of resolving that with a minimum of effort, if these principles are adopted: First, agreement by both the staff and line people on what are the specifications of a report. That would seem to be a simple thing. Try to find out how many people there are in the plant. Ask three different people and you will receive three different numbers. The reason is that one fellow will count as being on the pay roll someone who is out on leave of absence. The other fellow won't. One fellow

will count people by taking the total number of hours worked and dividing by the standard number of hours. Another fellow will do it differently. They come up with different answers not because they are stupid or dishonest but because their specifications are different. So if the staff officer and the line officer agree on who should and who should not be counted we settle the specification.

Second, having agreed upon the specification, the question of whose clerks and whose people are going to work up the information, to my mind, is immaterial. The rule that I certainly advocate in the case of industrial establishments is have those people do it and are already working in that kind of area and are familiar with the problems. That is the most economic way to do it.

Finally, provide an independent audit of whether the report actually conforms to the specification. That independent audit should be made, not by the line officer, but by the staff officer.

We do a great deal of that in industry, not so consciously as I have spelled it out. The classical audit is the independent financial audit made by auditors who are responsible not to the officers of the company but to a committee of the stockholders or the board of directors. Also, there is what we call in industry the internal audit, which is not a financial audit of the books but rather an inspection to see whether the procedures are following the intentions spelled out in the routines and the standard practice instructions.

In small companies there is not much of that, but in the very large establishments there is a lot of it. It has status. It is recognized. I would say the extent of it might be comparable to what we have in a government establishment although I can't say that with authority. The principle is certainly understood and accepted.

QUESTION: Doctor, would you discuss for a few minutes the principle of management by exception versus a stern management, knowing everything good or bad before anything is done?

DR. JURAN: That certainly goes to the heart of how to manage an establishment. The things that happen in industry take place in the first place in very small quantities. A foreman writes out a requisition for 3 pounds of that, 18 quarts of this, and so on. Time tickets show 3.5 hours for this job, 17 hours for that. Powers, supplies, machine utilization, and so on, come in small bits and pieces that are recorded in material requisitions, labor time tickets, invoices, and the like.

So we have myriads of facts, each one of which is relatively unimportant. The executive who is trying to become a human I.B.M. machine to collect all that stuff together and find out for himself what is taking place is just collecting ulcers. He has no business being in a job like that because the problem is to take that myriad of happenings,

each unimportant, and reduce it to a few facts, each of great importance. Those few facts are the things I defined at the outset--control points. They are funnels into which these bits and pieces of facts are going to be brought together. Whenever you see someone who gets a tremendous amount of detailed information day after day, big columns of figures, and the like, you can just know--because there aren't enough geniuses to be an important exception--that he cannot possibly have a grasp of what is taking place. Nobody can assimilate that riot of information.

The mark of the executive there is to turn back to the subordinates and tell them "I'm d----d if I am going to sit here and be an adding machine for you. Instead of 10,000 figures none of which is important, I want 25 figures each of which is vital." I could go into quite a story on that, the way in which the coming electronic machinery may make it possible to have actual indicators on the wall showing what is taking place. I will give you an example because it is not too farfetched.

Several years ago I saw at the refrigeration plant of General Electric, at Erie, several interesting boxes along the assembly line. Here, for example, was the station at which they test for leaks. If there was a leak, the operator making the test presses a red button on the box. If there was no leak, she would press a green button. The box was a device for computing percent defective. The indicator, instead of indicating volts or amperes, had a scale "percent defective," so that the operator and the foreman on the floor could read what was the percent defective.

The ingenious thing to my mind was that the same box was duplicated in the superintendent's office. The superintendent could read on the wall of his office the percent of leaky refrigerators far away out in the factory somewhere.

If we take that idea and expand it, we can visualize the requisitions for material, time tickets, and so on, being dropped into an electronic machine. The superintendent or manager will have on the wall an instrument which indicates the cost of the product; another which indicates the amount of production as it is taking place, and so on. That to my mind is the way you would like to operate the setup. It by-passes all the layers of opinion. If somebody is going to operate on the basis of facts, the facts have to come right from the firing line. The place is too big for this manager to go down and see for himself, it has to be brought to him, but in a way that by-passes all layers of opinion. We don't think we have begun to see the developments in this direction.

Perhaps there is even another development we might talk about here. That is, we are undertaking a pretty considerable change in industry in which we are getting away from the common laborer as a base for industry. It is the machine that is the base in industry now. The self-regulation of the machine is the next job to be tackled. That self-regulation involves the measuring of what the machine does and providing its own

self-correction, just as we have tried to do in the past for the common laborer. The task of the human being at the bottom of the organization is really design, maintenance, and the supervision of the machinery. The base of the industrial pyramid tomorrow is the supervision of machinery, not carrying stuff around, picking it up, and putting it down. That is the business of the machine.

I have drifted away from my point and I apologize.

The mark of the manager is his ability to deal with the important things, to deal with the plan of the future, to leave to the people down the line to deal with the lesser things. He should certainly avoid doing clerical work in a way that prevents him from doing the work of policy-making, decision-making, and the like. He can bog himself down with that, but after he has done it, what has he contributed?

QUESTION: An increasing number of us have approached the same tasks that you have approached here from the viewpoint of control. We have approached them, I think, primarily from the viewpoint of communications. I personally find myself so much in complete agreement with what you have stated that I hesitate to mention the small area of conflict, but I would like to do that.

First, just for a moment, on the agreement on your servo-mechanism principle chart, for example, the arrow that goes up to the left, that we would think of as classes of information. We would start there, too, so we are in complete agreement. As it moves down to the right, that is transmission of information. Then we have the integration of the information over here (indicating), and the recording of it and the transmission of that, and the return of the transmission back to the process. You call it closing the circuit.

But you seemed in the first of your presentation to set up almost as a primary goal measurement. I don't disagree with the desirability of measurement but it doesn't go in there from this other analysis as a primary goal. Let me illustrate how we sometimes control well without measurement by saying we all do pretty well driving a car and we don't measure anything. I wonder if you could suggest some criterion other than the 80 percent weight factor that would enable us to tell when to measure and when not to measure?

DR. JURAN: Well, if I understand you to say that the measurement is not something that is vital to understanding what is taking place--

QUESTION: It is very desirable but it may not be vital.

DR. JURAN: I think I would put the thing the other way around, that it is far better to start with the idea that measurement is vital and compromise with it only when the carrying out of it is forbidding.

Somebody mentioned here the control of the Defense Department. If we made a catalog of what problems posed the greatest difficulty, you would find they are the things for which they had no easy unit of measure really to start with. In the absence of a unit of measure, you have disagreement as to whether anything is satsifactory or unsatisfactory.

Take as an example this illumination here. They used to talk about the twilight and the gloaming or various other words but nobody could agree on what those things were. Only when somebody developed the unit of measures was it possible to compare one reflector with another reflector or one filament with another filament. Out of that came not only tremendous advances in illumination but made advances in astronomy and still other sciences because of the units of measure.

Take the problem of morale--that is something we don't have too accurate a measure for. It is only as we can begin to measure the AWOL rate, the veneral disease rate, other such things as can be counted, that we make very much headway.

I don't think we ought to compromise with the need for measuring. The need is always there and we should always have someone working on that. The limiting factor is when, in order to achieve measurement, you have to push back the frontier of available knowledge itself. That is when it gets to be tough.

QUESTION: In all these servo-mechanism principles, there is a basic element which is the time-constant going around there. About the only units of measurement we have in the Department of Defense is the winning of war. It is a little hard to parallel your comments about industry with the Department of Defense on that basis unless you go into the Engineering Department and start separating the overhead from the engineering production. Is there a method for the measurement of engineering production and separating the overhead out of it?

DR. JURAN: We certainly have a lot of that sort of thing in industry. I must say I want to register that I don't really agree with the first assertion you made about so few measures on the Department of Defense. I don't want to pass that by and leave the impression that I agree with that, because I don't.

But on the matter of the separation of engineering, let me give you an example. One large company does a good deal of developing new kinds of machinery.

A few weeks ago the chairman of the board of that company gave me quite a discussion on how, over the years he had been variously taken in by engineers going on and on with some development which just went on and on. There was always progress, but always something else was needed to be explored. It was an endless thing. So he got fed up with that and developed a plan for controlling the development of products.

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He has defined nine different stages of engineering. He also has defined the bases that this project has to touch before it may proceed to the next stage. For example, in his committee, when somebody has a proposition for some new engineering development, the first question is not "Is it technically feasible?" but rather, "If we had it, what good would it do us?" You see it makes a lot of sense. They answer that by having a market survey made as to how much market there would be for that thing if they had it. Then they explore the technical feasibility. They explore the question of economics. Then it comes back to his committee and it looks at it before the next stage of development is undertaken. That is a thought-out plan for regulating the engineering activity.

COLONEL KLEFF: Dr. Juran, on behalf of all of us, I express appreciation for a most interesting and instructive lecture and discussion period. Thank you very much.

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