300

ARMY INDUSTRIAL COLLEGE.
(Course, 1927-1928)

rd

EXECUTIVE CONTROL IN MANUFACTURING

Lecture by
George F. Doriot
Assistant Dean Harvard School of Business Administration

April 5, 1928.

EXECUTIVE CONTROL IN MANUFACTURING

By

George F. Doriot

Assistant Dean - Harvard School of Business Administration.

A manufacturing company is making a complex mechanism. A technical staff has been selected, machines have been made and sold, and the administrators are satisfied with the sales results and trend. The product is defined by a great mass of blue prints, not one of which the administrator can read, and by specifications involving technicalities-sometimes highly mathematical or chemical - which are Greek to him. But there are competitors making rival machines, and inevitable changes in design must be made to meet improved rival facilities. Specifically new inventions are made, and submitted to the administrator.

Upon what elements must he form judgments in order to authorize the embarking of the technical staff upon new lines? He cannot learn to read the blue prints, much less can he learn mathematics or chemistry. He has a trained technical staff, including a very good cost accountant. What must he know? Take an example:

A powerful administrator of a manufacturing company was won over to the idea of producing a new machine for type-setting. Very carefully, and with a full and technical knowledge of business requirements, he looked into the details of results claimed for the new machine. He missed no point in the manner proposed for using the machines, no point in the kin of results obtained, and he saw the novelties in the results which made a new contribution to printing as such. He considered the prices which could be obtained for the new machines, and the extent of the market. Here he found that the magnitude of sales was large at the prices possible and he was assured that costs of manufacture would fall far below the receipts, taking account of all fixed charges, life of the patents, and future commitments. But when it came to conversations about the technical details and the working theory of the new complex machines, he threw up his hands saying that the operations were completely beyond him.

Later on, when the first machine did not reach completion in the estimated time, and, in fact, when it was nearly completed, could not show the results upon which his enthusiasm was founded, he was in despair. He said, "I am helpless. I cannot understand this complex system, and I have embarked upon a beautiful dream which is not possible to realize, because it obviously involves new scientific complexities which will take years to bring into line with standardized operations of manufacture."

What should he have known?

He should have known that each single blue print of the machine called for parts which in no way required novel operations or any deviations whatever from standardized machine-tool operation. The assembled whole and the relations of the parts and the complex operation of them together, was beyond comprehension, but, taking <u>any one blue print</u>, as for instance

of a stell plate with dimensioned channels and with manufacturing accuracies stated. The administrator could not know why that shape was wanted, what it would do in the whole, but he could easily determine if any peculiar manufacturing operation was required. Like the hundreds of thousands of stamped parts in the world markets, here was another involving no peculiar requirement beyond stamping to limits which were easily determinable as lower rather than higher than the more costly established market actualities. This was true of each blue print and each specification taken in turn.

Therefore, though the administrator could not understand the massed relations of parts, and their complex motions, he should have looked for the trouble (1) in a search for glaring inconsistencies in machine-shop practice (casting,milling, turning, hardening, fineness of limits) in order to be sure that there was no novelty in segregated detail of manufacture and (2) finding no such deviation, he should have looked for fault in the carrying out of well known manufacturing operations.

Can he know what these processes are? Can the administrator, unable to take on the study of mathematics and complex relations in mechanics form a basis of judgment? He most certainly can. His study will not consist in the vast scientific generalizations which enable the technical staff to introduce manufacturing details in the particular order and distribution required for a given complex mechanism, but the administrator can work from the opposite end - that is to say, from a study of the elements of manufacture which are common to all machine works, whatever product they make.

The administrator in question, instead of throwing up his hands in despair, could have seen that his staff were shielding themselves (in neglecting proper machine shop practice in each case) under the nebulus talk of unknown complexity; that they took full advantage of the administrator's repeated emphasis upon the mystery, to him, of the wonderful "Thinking Machine" - a name he dramatically gave to it. It is to be remembered that we all apply an efficiently narrowed view and detailed concentration to our own particular profession (whether it be investment banking, or the design of electric oscillating circuits), but in regard to outlying professions, we attempt to judge them by broad generalizations. We must judge outlying operations by narrow generalizations: basic but simple common denominators. What are the simple common denominators in any operation? Very often they a re easily understood elements. If it be manufacturing chemistry, there will be temperatures and pressures used. Does the new commodity require extreme or normal temperatures? Is a required pressure well met by existing pumps? Never mind why the scientifi men want the pressure. First of all, are they asking for something never used by other manufacturers? If it be machine shop work, are any novel alloys required? Are the foundry men saying that here is a difficult requirement? They do not know why the pattern is of this or that shape, or how used, but they know at a glance (with no knowledge of its ultimate use) whether or not the casting falls in line with standard practice.

What are the required limits? Plus or minus two-thousandths of an inch? In steel? What sort of steel? We may not know why such steel is used, but is it broadly used already? And are manufacturers in our line

of product commonly working to plus and minus two-thousandths of an inch limit?

There are only four great categories to consider in regard to the questions so far touched.

(A) The manufacture of a product which is also supplied by other makers.

(B) The patented exclusive product where there is no competitive production and no basis of comparison.

(C) A new product just introduced which is not of Class B.

(D) Product made to order on contract according to outside specifications.

In all these classes, the points mentioned above apply. The administrator must be able to judge the work of the technical staff by a knowledge of the mechanical and other operations which have been standardized in manufacture. If a completely new process is introduced, he must take technical advice. But even in this, he must endeavor to acquire a narrow generalized view of the basis rather than the combined principles.

All the above applies to the mode of approach to costs. He must not search for identical complete assemblage costs, except in Class A, but should analyze the segregated costs. And in regard to separated costs, the emphasis must be placed on the importance of controlling total costs, and the relative effects of the respective costs if efforts to reduce the total are necessary. We will make this clear by an example taken from the above case.

After the type setting machine was at last brought to a paying basis, current costs were separated and shown in graphic form. One element of cost ran from $80 to $84, and experience showed that for the operations, labor and material involved in this range was economical. It compared favorably with similar machine shop and assemblage work in other plants. At a particular period this cost was running steadily at $82.50, which is very nearly the average of the limits - halfway between them. This was considered very satisfactory.

Then an increase in output called for an increase in power. It was necessary to double the output, and the increase of power could not be avoided. Moreover, the present cost of power was $12.30 per unit of product manufactured and new power would cost only $7.70 per unit, - an average saving per unit of $2.30 at the doubled capacity.

The accountant, hearing that the total cost of the product would be $2.30 less per unit, was satisfied with the proposal. Purchased power for the100% increase was quoted at a figure more than 30% above the cost of the power manufactured in the plant. Power costs would work out at $18.00 instead of $12.30 per unit of manufactured product. Thus the average power cost at double output would be $15.15 per unit instead of $10.00 per unit with its own power.

We mentioned above an important unit cost which was unrelated to power cost. It gave an idea of how some costs are more than others, and therefore require proportional attention.

Having regard to the fact that the administrator was consulted in regard to a capital expenditure for increased power, do you think he exerted his control sufficiently when he asked the Costing Clerks for the figures showing the effect of putting in the power plant and passed the proposal? He saw that own-power would effect an average saving of $2.30 per unit of manufactured product, as against an increased cost per product unit of $5.15 - having regard to the question of control over the economic situation.

What should he have known in technical analysis?

He should have considered whether it is wiser to expend the proposed sum, not on the power, but upon reducing, if possible, the more important item of $82.50, which varied from $80 to $84.

The power plant was installed, and it soon appeared that a rival firm, using expensive purchased power, had beaten them by installing special-purpose machine tools. The peculiarity of special-purpose machine tools in a works of large steady output is a reduction not only in cost but a reduction of variation - in itself a valuable condition for analysis and control.

The figures handed to the administrator had seemed to favor the new power plant, inasmuch as the new power was inevitable, and in showing that own-power would save $2.30 per unit product, and purchased power a loss of $5.15 per unit - a range of $7.45. And the Cost Clerk was satisfied. But the administrator's satisfaction must be general, and not segregated.

He must consider:

1. The question of time turnover on capital expenditure.

2. The relative magnitude of segregated costs, and more especially the respective ranges of variation.

3. If improvement is definitely possible, as a result of capital expenditure, and if of two alternatives, one brings a quick turnover and the other an equal or greater period of turnover, the administrator should consider the expenditure in connection with steadying at a lower figure those costs which show the greatest instability.

Control in manufacturing primarily has to do with the establishment and running of the efficient systems of operation and costing. But at the present day it is easy to adopt systems already established in going concerns and to choose the best adapted to the particular work in hand. It is not difficult to choose a technical staff nowadays, when men of

attested training are available. Once this is done, the running of staff work becomes largely a matter of routine. Beyond this, there is the question of determining the normal costs which must be adhered to; and a constant effort to reduce these costs is the main duty of the technical staff. But the staff must be segregated into special lines, and each department watches its efficiency and costs.

It remains for the controller to take the narrowed general view. We have above defined such a view; it is not a truism. Control consists in very much more than a grip upon steady efficiency among the staff of trained scientific men, each with his separate duty.

Cases which illustrate the above points will be useful, and the variable points of view must be shown in regard to classes named on page 4.

(A) The manufacture of product which is also supplied by other rival makers. Here you have a class most directly connected with users' demands. Apart from works efficiency, and the meeting of competitive manufacturing costs, there is to be faced an inevitable law in demand and supply: Prices are not in the long run to be based upon the cost of production. For when many rival sellers are in the field, the user has new facilities and improvements constantly suggested. The forgivable exaggeration of the rival salesmen when they are competitive producers, always accelerates the growth of imagined improvements and therefore a strong trend toward very much better products. And the law of demand and supply is that production costs are bound to meet the new quality of demand. Miracles are performed. We will almost say that <u>any</u> demand, if it be actual and pressing, will be met. Interatomic energy will be obtained when coal fields are exhausted, and the population presses too strongly upon supplies. This, however, is rather outside the peculiar growth of demand of Class A at the moment.

(B) A patented exclusive product, where there is no competition and no basis of comparison. It is a paradox of patent protection that the profits are increased after the patent runs out and rivals enter the field. This seems to show very simply that the patent merely gives a start to the owner - puts a handicap on the rival. But there is more in it at the start. Without patent protection, it is less than any one manufacturer's interest to do the pioneer work. Developments, and that most important factor - (The second layer of patents, which grow out of manufacturing experience) would, in an open field, be seized by manufacturers more powerful than the pioneer; and the man who starts early is the very one to be left behind.

There are various elements in patent protection, - some advantageous, and some disadvantageous. The impact of new supply upon potential users is narrowed by exclusive production, and demand does not grow as rapidly as under Class A. The question always is this: Will the sales and profits <u>per supplier</u> in an open field be greater than the sales and profits when <u>total initial</u> supply is smaller? There are cases where strongly restrictive patents yield profits smaller than the open field. This would have been true if the pneumatic tire had been too long held under exclusive patents. The public did not jump to the

idea of this new luxury in the late eighties.

Control, under which employed experts work at divers specializations is very apt to become humdrum. The danger lies in judging current efficiency as related to normal standards. But normalities and standards are dangerously unstable. Control must do more than preserve relative efficiency. In the case of patent protection, it is a very subtle and complex game. It has been often asked if an invalid patent can be valuabl There is a volume of thought involved here. It is a riddle with answers amazingly variable, and the knowledge required in the answers is a knowledge of industrial control, possible only to the synthetically imaginative administrator.

(C) A new product just introduced, which is not of Class B. Here, the speed of improvement, which accompanies all products, is necessarily greater than in Class A. It might appear that in Class A, where an open field is already broadly established, the competitor would force improvement at maximum speed. But it must be remembered that though independent producers may not be merged, their similarities of product tend to establish a stability against which the growing quality of demand above mentioned presses. In spite of this growth, a stability resists, and the necessary speed of improvement in Class A is slower than in Class C.

Rival sellers of allied but quite dissimilar goods, here not competitive in kind, tend to destroy demand for the Class C, as they may do in the case of a patented new product, but the producer feels that in as far as he succeeds in placing his product (in the initial stages) he loses his advantage to later copiers who have waited, free of pioneer expense, to enter the field.

(D) A product made to order on contract, according to specification. The grave danger here is, that, if the product be new, the middle-man learns the methods and limits from his first manufacturer. The manufacturer, though he benefits by experience (the methods and limits of a new product are invariably improved or modified) naturally takes account of his capital expenditure in such a way as to avoid too much scrapping of plant. But the middle-man looks, in many cases, to going to new producers who are free of initial experimental investment. Contract is difficult to draw for adequate protection, and the controller must make very great efforts to obtain perfect definitions of limits and allowable variations of quality.

Corporations ultimately look to one man whose duty lies in correlatin the many different departments. This is the controller per se, but control is greatly affected by matters which merge into other lines of work, such as Policy - financial and technical.

We are here making a study of the technical aspects and we emphasize elements of technology which the controller must know. And when you have studied such subjects as Policy, lying beyond the immediate elements of technical manufacturing control, you must see where these different

subjects affect control. We are bound to divide a system into separate efficient departments arranged to run automatically (there is no question of the advisability of employing specialists for different sections of work) and we begin by setting up actual standards for each department. But what is today an ideal in a given department may to-morrow become, under a general survey of control, inefficient when taken with the whole. The danger lies in this, that a controller will receive reports from many departments, each of which is very satisfactory, and he will not see that a re-shuffling is necessary. This is illustrated above by the case in which both the Power Engineer and the Cost Clerk showed a very apparent reduction of costs and an increase of facilities. No consideration was given to the other departments. It is to be emphasized that when any important alteration is proposed in manufacturing, if it involves expenditure, all departments must be reviewed to see (1) the relative efficiency of the proposed change and (2) the possible effects upon other departments. This involves technical knowledge on the part of the administrator, and we are here concerned with the nature of this technical knowledge. We repeat that it should not be gained by a study of specialized types of technique in terms of those specializations, but in terms of the elements common to all of them. An example follows.

It is true that the business of manufacturing gramophone records differs vastly from the business of making pneumatic tires, but the essential questions of control in manufacture, on the technical side, show similar elements. Questions of trade secreta, although chiefly dealt with under the heading of Policy, can greatly affect the run of works control in such different things as rubber manufacture and in gramophone record-making, and the controller must know how far the set Policy affects him.

The Rex Record Company carefully guarded their process of record-making and their process of electroplating, and arranged the works so that men in one department did not see the operations in another department. In this case, the appearance on the market from time to time of an improved record did not reveal to the competitive manufacturers what had been done.

Was the controller of the Rex Company justified in his policy of guarding trade secrets? Was there another element more important to gauge?

It is true if all competitors in manufacture allowed their processes to be known, the open field, as in universal Free Trade, might easily give greater profits to all manufacturers as we suggested above. But was there any reason for the one company (Rex) to consider a relaxation of insulating the operations in their works? Certain operations and conditions had been discovered, in former years, in the depositing of copper on the wax records, and at the time these had been very valuable. The works controller could not allow visitors to see the department, nor allow the process to be mentioned to outside people. But one day by accident he let a detail slip out in talking to the manager of a very

different business - a business which dealt with rust protection. The manager of the Rust Protection Company spoke of electroplating in general, and said that his company welcomed plating experts at all times to see their process, and that they had abandoned secrecy, because in an open field, they were able to have the criticisms of new workers and to keep in touch with improvements which might have peculiar value in their processes. A suggestion that the Rex manager should open his department to the electro-chemists he strongly resisted.

Instead of that, he isstituted a research, in which an expert sought to adopt better methods. The research expert, like all technical experts, kept in touch with other specialists and watched for improved methods applicable to the special Rex manufactures. But when he conversed with specialists, he could not tell them his conditions, and he missed, over and over again, advice which could have been given instantly if the exact conditions had been stated. All would have been well if the research man had been a very great genius with the learning and the time to appraise new discoveries and to see their exact relations to the Rex process. But no one expert can reach these heights.

Finally, it was seen that a rival company, who had all their electroplating done by the trade, were making gramophone records better than the Rex. The technical superintendent of the Rust Protection Company was shown over the Rex department. In half an hour, he proposed to scrap the secret process, and to adopt new methods. The results immediately increased the profits of the Rex Company, and there is today no secret in their method.

The benefit here illustrated is an exact analogy to the conditions analyzed on page 9 in connection with Class B.

In the recording department, a similar mistake was made. All the rival companies had wonderful secrets connected with recording. The Rex controller felt that he could not comprehend all the scientific talk of the record makers. His staff were highly trained, and their shop-talk was of sound waves, upper partials, harmonics, the cochlea of the ear and what-not. Effort under these conditions tends to seek out secret differences as often as it tends toward broad analysis. It is instinctively felt that all the applicable knowledge is held by the various recording companies, and as these will not combine in a discussion of their special problems, how else can any one company advance unless it be by secret research? The controller, if his record-manufacturing process was open, could more quickly learn the essential principles of the technique broken down from puzzling scientific specialization.

The new Orthophonic gramophone has been the result of at least a partial opening up. It would certainly be better for one company to overcome a defect when threatened (as all phonograph companies were threatened) even if rivals benefit by the improvement.

We are not saying that there are no trade secrets to guard. But the essence of manufacturing control, on the technical side, is a knowledge of the processes common to all manufacturers rather than an a attempt at scientific knowledge of one special process.

Some years ago, the Goodrich Rubber Company, at Akron, Ohio, had wonderful restrictions on their secret processes. today very much is in the open field. The new method of depositing rubber by electrostatic means is well known, and has the benefit of open discussion. And the Goodrich Company makes more money out of using it than if they had followed the slow evolution which is characteristic of trade secrets.

Control in manufacture involves a great mass of routine work not touched upon in the above remarks. This may be summarized as follows:

1. Allocation of work to use plant efficiently.

2. Relative urgency of orders.

3. Running costs and fixed charges.

   (a) Salaried staff with the separated categories of technical work and their mutual relations. The drafting office and the manner of input of designs. The clerical staff and the current money control.

   (b) Plant use and costs and upkeep under appropriate head.

   (c) Plant improvements and additions.

   (d) Wages and systems of payment.

   (e) Questions of shop conferences.

4. Information for the purpose of analyses.

On the purely technical side, the subjects into which the necessary study can be broken down are:

1. Elements of mechanics - transformation of motion

2. Manufacturing equipment.

3. Material and tool transformation.

4. Examingation of product to be manufactured.

5. Choosing equipment.

6. Testing and specifications.

7. Power.

8. Movement and coordination of continuous processes.

9. Fluctuation in value of fixed assets.

10. Unit cost.

11. Economic size of lot and study of stock accumulation.

12. Comparision in terms common to all leading industries.

These are dealt with under the respective titles.