AUTOMATION: ITS IMPACTS ON LABOUR

——A Case-Study at Thermal Power Stations in Japan——

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Introduction

Aids or assistance given by the advanced countries to the developing countries are meant for the removal of elements detrimental to economic development in the latter. These elements harmful to economic development, however, do not exist in uniform manner, working all at once, in each of the aid-receiving countries. It is, therefore, essential, if the aids are to be successful and fruit-bearing, to have a far-reaching perspective of the long-term economic growth of the recipient countries and to be well prepared for a number of critical-paths at various stages of their uphill journey towards economic prosperity. As to the substance of the initial 'critical-path' often encountered in the developing countries, the problem of "human resources" appears, more or less prominently, among others. United Nations came to take good note of it, and qualitative improvement of the human resources in the developing countries has been sought under its "Expanded Program for Technical Assistance."

Technical assistance meant for development of human resources, by the way, is seldom free from the problem of "behaviour-pattern" which is particular to the people in the beneficiary countries. No two countries share the human resources reacting in exactly the same manner to the same stimulus. The differences in their mode of reaction reflect the differences of their historical, climatic or social ways and customs, all combined into one "behaviour-pattern." It might, therefore, be rightly argued that the uniform pattern of technical assistance would not be of equal effectiveness towards every kind of human resources, each with different background, and the best effect can be expected when the method of assistance is precisely adapted to the particular behaviour-pattern. In this context, the detailed analysis of different human resources comes to assume its importance. What is going to be taken up here, however, is not a general concept of abstract nature but an analysis into the difference of behaviour-patterns towards newly introduced technique in particular. Among many methods available for such analysis, one effective approach would be to check the behaviour of the human resources in a specific marginal situation, determining differences in behaviour-pattern revealed in the process of workers' adapting—under strains—to a newly introduced technique which would sound almost revolutionary to the one already existing in their country. Once this is possible, the technical assistance given to any country could be properly adjusted, for the best ultimate success, in the light of the peculiarities of workers' hehaviour-pattern.

What modern technique can be 'almost revolutionary' to the technical level known to any country? It would be synonymous with the most advanced technique of the modern age. People may take a number of names for it; yet, the consensus of opinion will fall on that of automatic control. Automatic control technique played a leading role in the Second Industrial Revolution which almost all the advanced countries of the world experienced after the Second World War. The First Industrial Revolution liberated the human being from his existence as a source of energy and made him rather a controller of energy. The Second Industrial Revolution, then, went so far as to deprive the human being of even his role as the controller of energy. What followed in his place has been the automatic control mechanism. In a sense, it is a mechanical embodiment of the function of human brain—at least a part of it. Noteworthy has been its technical advancement in the last decade which is still going on. Introduction of this technique was accompanied understandably by a not inconsiderable resentment among the workers in the advanced countries of high technical levels. For workers in the developing countries generally hovering on a low technical level, it would simply sound revolutionary. In this article, the readers will be shown how the Japanese engineers and workers are being adapted to this 'revolutionary' technique.

Since the beginning of the 1950's, large thermal power stations came into existence in this country, one after another. They were built on modern ideas mainly from the USA and were meant to be as automatic as possible. Under these circumstances, Japanese engineers and workers had to acquire the operational technique of such automated thermal power stations through various processes. The author does not mean to limit his purpose only to the Japanese example; he rather wishes the concept and methodology of this case-study to be profitably taken into reference for determining the differences of behaviour-pattern among divergent human resources each with their own background.

I. Substance of Labour in the Automated Thermal Stations

To begin with, let us inquire into the problem of what kind and how big a change has been brought into the operational labour of the traditional thermal plants by introduction of automatic control mechanism. The Tokyo Electric Power Company, Inc., a representative power concern in Japan, has a number of thermal power stations. Three of them have been selected for our study, as per Table 1. An analytical study has been made of their boiler part.

Boilers Nos. 1–6 of Tsurumi plant are running on a lump-coal firing system, with a very poor thermal efficiency of 16.7%. The type in this plant is one of the oldest owned by the Tokyo Electric Power Company, Inc. On the other hand, Chiba plant (with Boiler No. 4) started operation in 1959 with the excellent capacities of 17.5 MW output and 38% thermal efficiency. It represents the typical thermal plant with automatic control mechanism in

Table 1. CAPACITIES OF THE THERMAL PLANTS UNDER STUDY

	Tsurumi Thermal Station Boilers Nos. 1–6	Ushioda Thermal Station Boilers Nos. 1–4	Chiba Thermal Station Boiler No. 4
Output	3.5 MW	3.5 MW	17.5 MW
Thermal Efficiency	16.7%	21.5%	38.0%
Number of Turbines	2	2	1
Number of Boilers	6	4	1
Steam Temperature	38.2°C	37.1°C	566°C
Steam Pressure	24.6	25.6	168
Type of Combustion System	Lump coal firing system	Pulverized coal firing system	Pulverized coal firing system
Year of Construction	1927	1931	1959

Japan today. The Ushioda plant may fall between the above two, running on a pulverized coal firing system like Chiba plant, but equipped with boilers not very much superior to Tsurumi in steam pressure/temperature. Our study is concerned with comparison of operational labour between these thermal plants which are automated in different degrees. Our purpose is to determine which part of the human labour is being replaced by the technical advance.

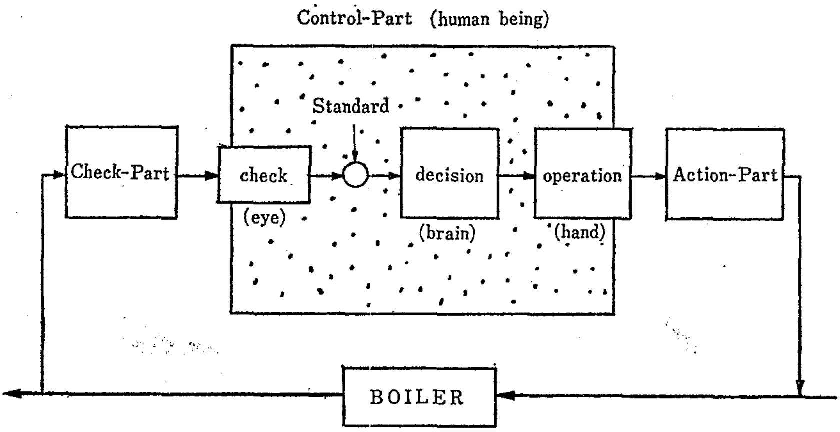
Now, output shall be regulated strictly by the demand for electric power. The greater the demand, the more the output, and vice versa. Input, therefore, has to be controlled according to output. The boiler is given its own capacity which may not be violated beyond limits. Input shall be regulated so that the calory in store of the boiler will maintain constant in view of the amount of output. The operational labour called boiler-burning is primarily meant for this purpose.

The operator keeps on checking metres which indicate the amount of energy held inside the boiler and, comparing the actual values (steam temperature/pressure, etc.) with their standards, he is constantly required to decide how much of any increase or decrease in energy-input is being called for. He controls the amount of energy put into the boiler by adjusting gears and notches by his hand(s) and/or foot(feet). The results of his adjustments he has to ascertain through metres again. In this way, his labour completes a sort of 'cycle': the result of a certain operation starts a new phase of it which again brings about the result of succeeding operation. The cyclical process of such an operation may be best illustrated by a loop of feed-back as per Figure 1. A set of metres is named as 'check-part' because it is to check the conditions prevailing inside the boiler; the mechanism for comparison with the standard-values and for decision of the extents of operation, as 'control-part'; and the mechanism for direct manipulation of the inflow of energy into the boiler as urged by such decision, as 'action-part.'

Within this framework of mechanism, the operator occupies the post of 'control-part' within the cycle. His position and its relationships with others will be simplified as per Figure 2.

Input to human being originates at 'check-part,' and after being trans-

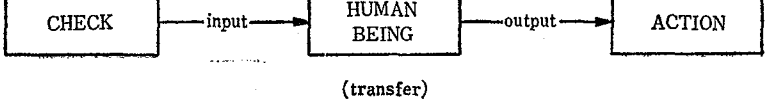
Figure 1. MODEL OF LOOP OF FEEDBACK



ferred through the human-being, goes to 'action-part' as output. In other words, *output* in term of operation is a response to *input.* The substance of the operator's labour may, therefore, be divided into three parts: the first, the receiving of input from 'check-part'; the second, its transfer; and the third, operation as output. The first being a passive and nervous type of work and the second being intra-brain operation, it is very difficult to directly measure the intensity of labour involved in these two kinds of work. Fortunately enough, however, the third part of the work can be measured with indisputable accuracy. Moreover, it materializes as the sequence of the first and the second parts of the work, for one thing, and it can be expressed in a closed loop, as will be seen from Figure 1, for another. It will not be illogical, then, to take this third part of the work as an index of the whole labour required for boiler-operation. Unless we choose this approach to the problem of labour, we cannot escape the pitfall awaiting us with illusions such as "mental labour" or "mental load," etc. Studies on labour connected with automation have often been fruitless mainly due to this fault.

Results of actual measurement of the boiler-operator's labour from the above viewpoint have been spread in Figures 3 and 4. It will illustrate the differences existing in the intensity of labour (average of 5 minutes per unit hour of measurement) among Tsurumi, Ushioda, and Chiba plants. On the horizon which represents "thermal efficiency" are plotted three different plants each with different degree of automation; "labour intensity as output" as measured at these plants is given vertically.

Figure 2. RELATIONSHIPS AMONG CONTROL-, CHECK-, AND ACTION-PARTS



In Figure 3 are shown a few curves, each representing values for different types of work. " Start-stop operations " consist of labour required for starting or stopping the boiler, while ' load-change operation' of labour call for adjustment of the outflow of steam from the boiler according to the demand for power generation. Pulverized coal firing boilers at Ushioda and Chiba plants are not free from jamming of their coal-powder feeding-pipes. Recovery of normal feeding mechanism by clearing these pipes is indispensable for proper functioning of these types of boilers. Though it does not mean a strenuous labour, it is called for as restoration of a sort of " accident " and is rather important. Therefore, it is shown specifically as " adjustments of the coal feeder-troubles." Except for those kinds of work which are required to meet with atmospheric changes, the routine operational duties are grouped together as ' normal operation.'

It can be observed from Figures 3 and 4 that there is a considerable variation in categories of work-load among these three different thermal plants. In ' start-stop operation,' work-load difference between Tsurumi and Ushioda is extremely large, while that between Ushioda and Chiba is comparatively slight. The situation is completely reversed in the case of 'normal operations' : a little difference between Tsurumi and Ushioda but a considerable gap between Ushioda and Chiba. Inspite of the opposite pattern of

Figure 3.

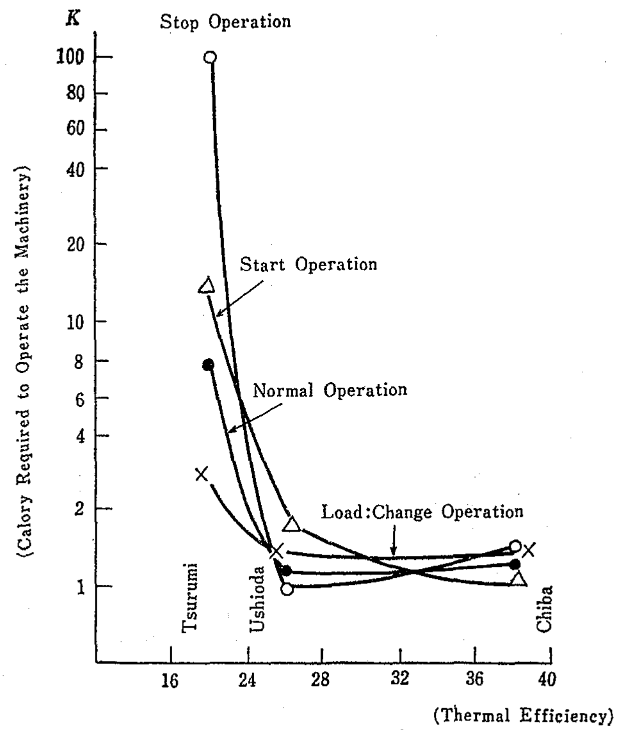
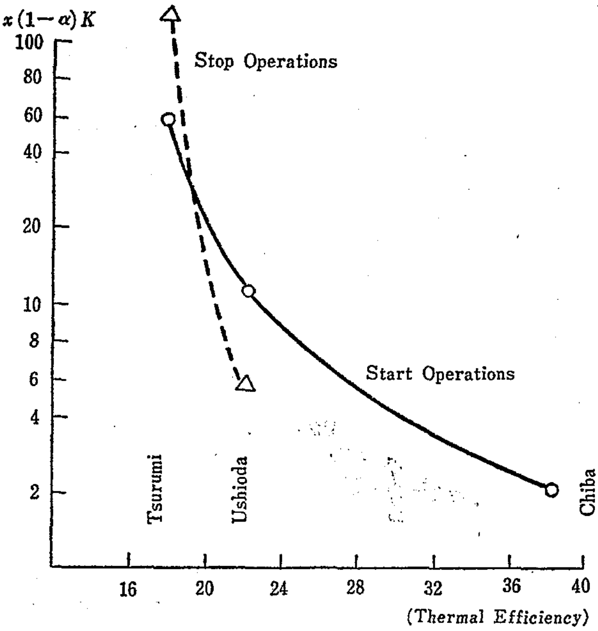


Figure 4.

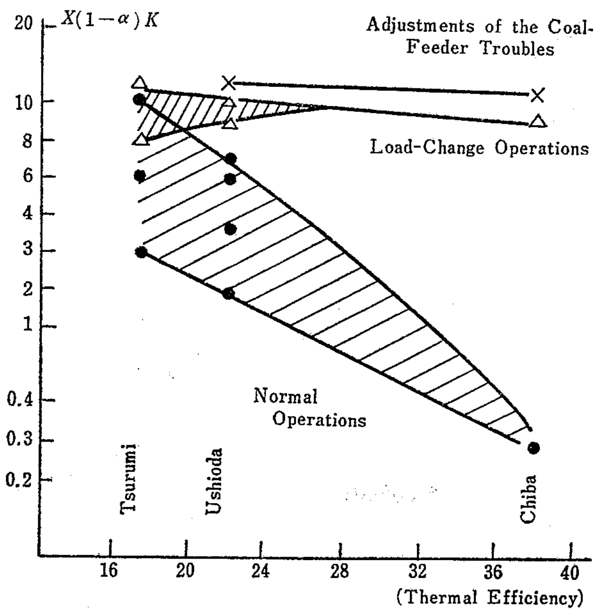


category differences, the work-load shows a declining tendency, running counter to the degree of automation, from Tsurumi downward to Ushioda and Chiba.

There are two kinds of operation, however, wherein the innovation of facilities (automation) does not alleviate work-load to any appreciable degree. They are 'adjustments of coal-feeder troubles'—a type of repair-work—and 'load-change operation.' Two horizontal lines running between three plants on Figure 4 stand for such a phenomenon. The magical term "automation" gives people an image of a workshop where each and every part of the labour is grossly done away with. It will remain a mirage as far as a thermal plant is concerned. Labour can be and actually is drastically alleviated in some fields of work but, in others, it remains almost as before.

We shall now examine the problem of why alleviation of labour results in some part of the work but not in others. Another set of models which are derived from the idea of man-machine system will be introduced for this purpose. Previously, the operational labour has been grasped in term of input-transfer-output and the work-load borne by such operation measured in "output as a response to input." Now, we shall have to confirm those conditions related to the amount of labour taken as output. *First*: the more the input the more the output, the latter being a response to the former. The response, however, may not necessarily go through human beings. The amount of labour that matters shall be limited to that responding through human beings. *Second*: the more the degree of dependency of the automated mechanism on human beings in the transfer of work, the more the response through

Figure 5.



human beings. *Third*: the more the work-load required to operate the instrument and machinery—operation by human beings in response to input—the more the human energy consumed per response. This will be illustrated by Figure 5.

Input as it enters into 'control-part'..............(x)

Input transferable to 'action-part' through the filter in the 'control-part' may be divided into two parts: one through automatic control instrument and the other, through human beings. 'Control-part' filter liable to more or less automation may be expressed as ratio of automation............(α)

Amount of response through human beings may be calculated by the formula given below:

Input (x)×[1−Ratio of Automation (α)]$=x(1-\alpha)$.

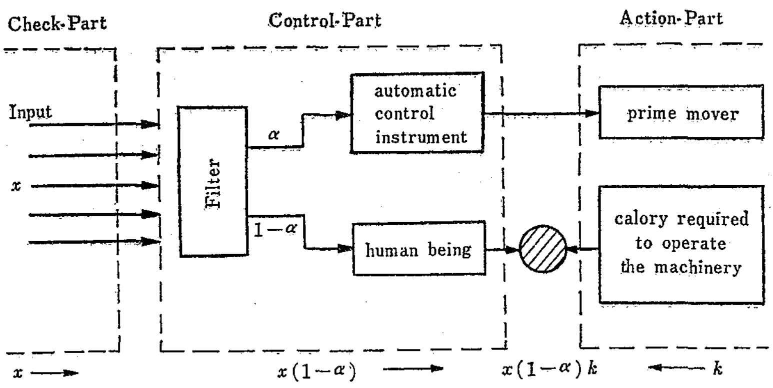
Amount of labour, when transferred to 'action-part' as output will be measured as the multiple of 'calories required to operate the machinery' (K) or $x(1-\alpha)K$.

Accordingly, the analysis of the amount of labour can be replaced by that of x, $1-\alpha$ and K.

Coming back to Figures 3 and 4, let us analyse the amount of labour $x(1-\alpha)K$ in each of x, $1-\alpha$ and K.

To begin with, the value of "K" required for operation of machinery. Figure 6 shows different values of "K" required in each different kind of operation in three plants. The results are most apparent: almost no difference in the values of "K" between Ushioda and Chiba plants, while Tsurumi

Figure 6.



seems quite independent to those of the former two. Figure 6 thus reveals the fact that there is a great difference in the kind of machinery to be operated, or, in other words, a difference in the nature of machinery-operation work, between Tsurumi and Ushioda, on one hand, and Chiba, on the other.

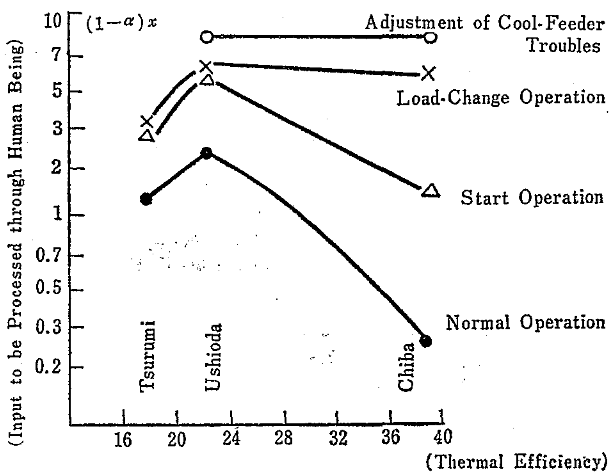
Take, for example, the regulation of the volume of air through a ventilator. Air-supply is controlled by operation—opening or closing—of the damper. In Tsurumi, the worker has to manually operate the damper; that is, the opening and closing of the damper is done by human hand. In Ushioda and Chiba, however, switching on a motor is all what is required of a worker. The motor works by itself on the damper. It can be put in this way: in Tsurumi, the worker has to deal directly with the ultimate object of control and he himself functions as a 'control-part'; but in Ushioda and Chiba, the manual labour is being replaced by a set of machinery in-between, the result being a wide fall in the value of "K" in Ushioda and Chiba compared to Tsurumi. In short, the development which took place from Tsurumi to Ushioda was achieved through elimination of human labour from the 'action-part' and the most proper term to express this phenomenon must be "mechanization."

Next come the problems of x and α. They can be handled separately but we put them together here as $x(1-\alpha)$, from the viewpoint of "input which needs to be conducted by human being." A slight fall of Tsurumi below Ushioda is attributable to the difference between two firing systems (lump coal firing system vs. pulverized coal firing system) or to that in "x" and not to that between α. What needs attention here is the relationships between Ushioda and Chiba. Both of these plants are equipped with pulverized-coal-firing-boilers and, therefore, there can be but little difference in x value. If there is any difference, then it will be solely responsible to α. The value progressively increases in order of 'adjustments of coal-feeder troubles,' 'load-change operation,' 'start-stop operation,' and 'normal operation.' In this order the ratio of direct mechanical—not human—transfer increases in a total input; that is, the function of the human brain is accordingly replaced by machinery. The reason why value is not the same among all types of work stems from the problem of the controlling capacity of machinery employed now. The human brain is the most excellent control instrument so far available. Coal-feeder troubles, for instance, which may mean a kind of accident involve far too complicated a repair-job for any existing control instrument to solve automatically. In this case, all the input is properly transferable only through a human being. This is the reason why the value for coal-feeder trouble adjustment stands on the same level in Ushioda and Chiba as shown in Figure 7.

Both in 'load-change operation' and 'start-stop operation,' value owes its fluctuations to the adaptive speed for load-change as required against that possible with the controlling machinery in Chiba plant. 'Load-change,' by the way, means the timely alteration of the output steam flow from the boiler in tune with the change of the demand for electric consumption. Fairly quick action is called for in this operation, and the existing machinery with its designed speed can hardly transfer the input as quickly as required. The alternative is the brain—an excellent control machinery with which every human being is endowed.

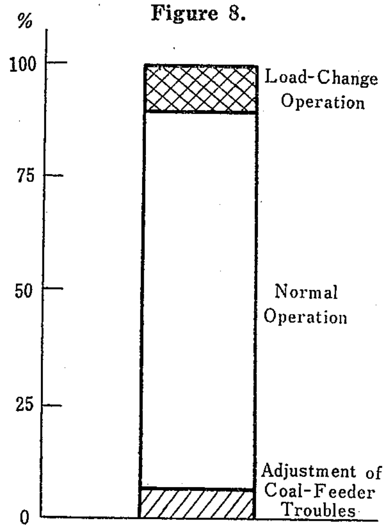
In case of 'start-stop operation,' alteration of boiler conditions does not demand as much speed as is required in the case of 'load-change' because it is meant for the prevention of boiler-failures. This allows the control instrument more chances to function. Thus the sphere wherein the automatic control instrument is given full hand to outdo the human brain remains in 'normal operation' alone. In other domains the human brain still holds the commanding post, with control machinery as its aid. This holds true in the thermal plant which is generally supposed to be a workshop wherein automation has been given its most extreme industrial application.

Figure 7.



The proportion of work by length of working hour, among 'normal,' 'load-change' and 'start-stop' operations in the Chiba plant is given in Figure 8. Normal operation occupies an overwhelmingly 88% of all the working hour. For the most of their working hour, the labourers are engaged at 'normal operation' in which α or automation ratio has greatly increased since the days of old facilities. When measured as a whole, therefore, boiler-operation in the Chiba plant which has attained a high-degreed automation is made up of very much different labour-contents compared to the similar labour carried on amidst the obsolete facilities.

Figure 8.



II. Labour Proficiency in Automated Thermal Power Plant

In the preceding Chapter, some analysis has been made into the problem of labour-contents in highly-automated Chiba plant in comparison to those in other plants and the existence of a substantial difference has been shown. We are now going to look into the problem of labour proficiency under such new techniques. We approached the problem of labour-intensity in the thermal plant with the tools of *input from 'check-part'* (x), ratio of automation in 'control-part' (α) and *calories required to operate the machinery* (k). Findings obtained so far revealed that the technical change from the least modernized Tsurumi to Ushioda was made in the aspect of (k) and that from Ushioda to the most-modernized Chiba was in the field of (α). 'Control-part,' as has already been studied with Figure 2, functions in transference of input from 'check-part' to output for 'action-part.' This can be expressed by the following formula:

$A=f(E)$ E=input from 'check-part'
A=output into 'action-part'

'f' here stands for the function of 'control-part.'

A progressive replacement of human labour by machinery in 'control-part' is the trend of technical innovation called "automation." Here we have to ask ourselves: Is there anything like the progress of technical proficiency in operational work of transfer? If so, how such proficiency can be attained?

Figures 9 and 10 show the frequency of operation per 5 minutes of the workers with different length of experience in boiler-operation. Imagine that the input from 'check-part' deviates from the standard values; the 'control-part' must send output to 'action-part' to correct it: a worker with better efficiency in transfer-technique will neutralize such deviation with less input than the worker who is less efficient in the job. In short, the worker who can neutralize a given deviation (as shown by the indicator of the metre pointing to a certain degrees beyond the standard values) with five operations is supposed to be less "efficient" than the other who can do so with one or two operations. In Figure 9, we find: (a) a fairly high frequency of operation with a group of workers having 15 months' experience; (b) a sharp drop of operation-frequency with another group having 27 months' experience; and (c) 27 months' experience onward, no decrease in operation-frequency. One may take this as the maturity of technical proficiency reached after 27 months' experience, or the situation of attained proficiency falling at completion of that long a period of operation.

Figure 10 concerns 'load-change' operation along the similar line. In this case, (a) the least experienced has a rather low frequency of operation; (b) operation-frequency climbs up to a peak with the worker having 27 months' experience (then frequency drops as experience increases); and (c) operation-frequency curve continues drops and does not assume horizontal course after a certain length of experience as in the case of 'normal' operation.

The situation of attained proficiency is not being reached even after 45–50 months' experience on this Figure. Load-change operation is far more difficult a job than normal operation. Proficiency in load-change operation, therefore, does not mature within the period of time which is normally more than enough for that in normal operation. Low frequency of operation with the least experienced worker as shown in the same Figure is *never* due to his excellency in 'transfer' technique. Other surveys made it clear that it is due to the worker's "fear" of the facilities. Confronted by the automatic facilities for the first time, the size of the machinery itself is big enough to overwhelm him and robs him of any courage to operate it. Steam-pressure or steam-temperature may deviate to more or less degrees from the standard-values

Figure 9.

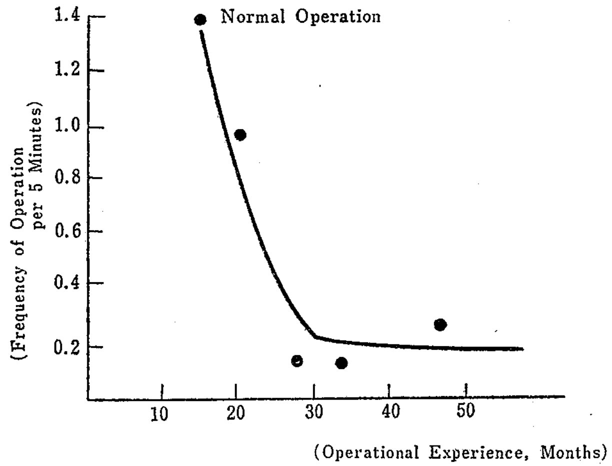


Figure 10.

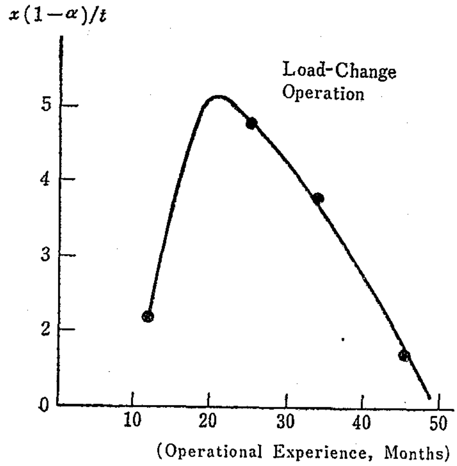
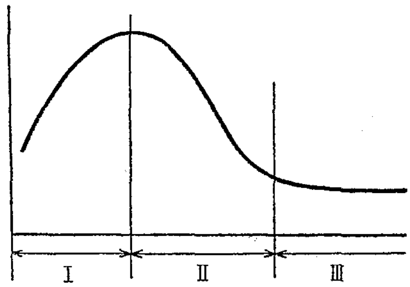


Figure 11.



Notes:
I: Period or Stage of Maladjustment.
II: Period or Stage for Maturity of Proficiency.
III: Period or Stage of Attained Proficiency.

before his eyes but he would not, or rather cannot, touch the machinery until and unless such deviation reaches a danger-point. His timidity gradually goes away, however, as his intimacy with the machinery increases. Then, the frequency of his operation will go up accordingly. After a certain period of time, it assumes a downward curve until it comes to stay at a specific level.

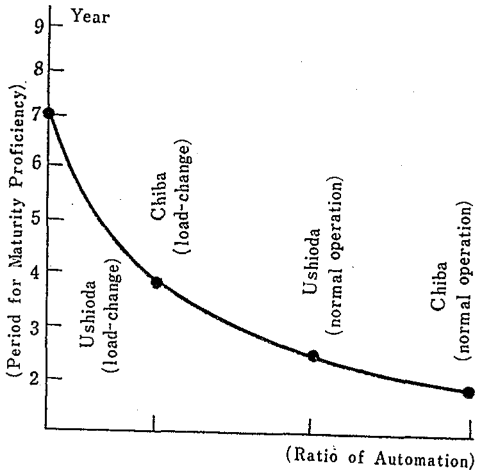
The process of attaining operational proficiency in "transfer," as measured by operation-frequency per unit of hour, may be shown by a curve with three different stages, as per Figure 11.

The first is the stage of 'maladjustment' and the second, the stage for 'maturity of proficiency' where the frequency of operation gradually comes downward. The third is the stage of 'attained proficiency' where the frequency of operation comes to stay on a specific level.[1] Assuming the span of time extending from the beginning of the stage of maladjustment to the entrance of the stage of attained proficiency as a period required for perfection of technical proficiency, our current concern must be to ascertain the length of time which is required for mastering the technique infused with different degrees of automation. Our study to determine the relationships between the ratio of automation (degree of automation of the facilities) and a period of time required for technical perfection under such circumstances brought us the results which are plotted on Figure 12.

In the Ushioda plant where the ratio of automation is not high, it took 7 long years for a worker to master his technique of load-change operation. The higher the ratio of automation, the less becomes the time required for

1 The process for maturity of proficiency has been identified not only through measurement of the operation-frequency per unit of hour but also by other methods including calculation of standard-deviation of steam-temperature, density of carbonic acid gas, etc. No details will be given due to limitation of space. See Shōji Shiba (Yasuhiko Ōishi ed.), *Ōtomēshon to Rōdō* (Automation and Labour), Tokyo, Tōyōkeizai-shimpō-sha, 1961.

Figure 12.



the purpose. It is only about 2 years in the case of 'normal operation' in the Chiba plant where automation is supposed to have been carried to its furthest extreme to date. Introduction of automatic control technique thus points to the direction for a drastic cut of the time required of a worker for attaining technical proficiency. One important comment necessary in this connection is that while automation helps shortening the time for technical proficiency, its effects stiffen at a certain level and cease to work any further beyond that. Figure 12 shows that automatic effect on apprenticeship-period comes to a standstill at the level of 2 years or so. The author made a series of similar studies in various automatic plants besides thermal plants and their results consistently fell on approximately 2 years.[1] It might also equal the quality inherent in human resources available in Japan. Its answer shall be sought through the comparative studies of international coverage in future.

III. Labour Adaptability in Automated Thermal Power Plant

As has been studied in Chapter I, there is a great difference in labour-contents between the new and old thermal plants. This is strongly reflected by the psychological fear or uneasiness among the labourers working in the old-type power plants towards automation. Their adaptability to new working conditions and modern machinery will be highly accelerated by removing such uneasiness from their minds. Its methodology deserves a careful study. Tokyo Electric Power, Inc. is employing a particular Foreman Training for this purpose. Operators of the old-type thermal plants are called together at the Chiba plant, the most advanced of all, to undergo one month's training on the operational technique of a modern thermal plant. At the end of each training-period, every participant is asked to submit papers describing his impressions of the experience. These papers will allow the examiners to evaluate the degree of understanding of the operational technique of the automated thermal plant at Chiba by each participant. All the papers are sorted into 3 groups, A, B, and C, in order of understanding or comprehension of the technicalities by writers. Here is cited a portion of writings from a paper which was

1 See Shōji Shiba, "Rōdō-ruikei to Jukuren-keisei-katei (Relationship between Man-Machine System and Technical Proficiency)," in *Sangyō-kyōiku-keikaku-shisetsu Kenkyū-hōkoku-sho* (Study Report Series of Planning for Industrial Education), No. 4, Faculty of Education, Hokkaidō University, 1964.

grouped into C, or of the participants showing the poorest understandings.

"... Entering Chiba plant, I was so astonished by its atmosphere that my sight went dim. It took one month before I could see every corner of the plant. In the meanwhile, how could I have had the courage to touch any of the machinery here?..."

Operational technique of the automated plant was far above this overwhelmed worker. B group participants, however, could somehow or other grasp an outline of the brand new technique within one month after recovering from the initial knock-down feeling shared by C group people. Mr. Y's paper will illustrate the difference.

"... At the outset, I felt myself a miserable and inferior creature in this enormous, orderly plant of advanced automation. ... But as days went by, I came to breathe the air of this Chiba plant more freely and the technicality of its operation stopped making my head swim. Now, at the close of the training, I feel myself well informed of the machinery and the operational process as a whole."

Those who belong to A group, on the other hand, show their complete understanding of the operational technique of the modern thermal plant. To cite an example:

"... To us who have been accustomed to old-type thermal plant operation, it looked mighty strange and understanding did not come so quickly. Frankly speaking, it took some time until I saw the whole picture of the show but, then and there, initial doubts in my mind disappeared like frost in the sun. Once they were gone, new doubts came to my mind. Pushing them on and on, I came to be greatly interested with many new exciting problems which, though not seen from the surface, were nevertheless quite challenging to me."

How much variation in their colourful impressions and reactions! They underwent the same experience during the same period of time among the automated establishments. Why, then, the difference in reactions? Five factors have been taken into consideration and a technique of statistical variance analysis has been applied to identify which one of them is most influential in differentiating their understandings. The factors were: (1) Length of Experience; (2) Age; (3) Educational Background [prewar college (14 years schooling since 7 years old), prewar high school (11 years schooling since 7 years old), prewar higher elementary school (8 years schooling since 7 years old) and postwar senior high school (12 years schooling since 7 years old)]; (4) Kind of Job (boiler, turbine, and electric apparatus) and (5) Parent Plant (by order of year of construction: Hitachi, Sumida, Senju, Tsurumi No. 1, Ushioda, and Tsurumi No. 2).

Figure 13 shows the distribution of A, B, and C groups according to the length of experience. The conclusion seems to say that the length of experience is neutral (it still needs to be borne in mind that this conclusion has been drawn from those who have had not less than 4 years experience). Other surveys already confirmed that the experience in old-type thermal plants

Figure 13. RELATIONSHIPS BETWEEN EXPERIENCE AND UNDERSTANDINGS

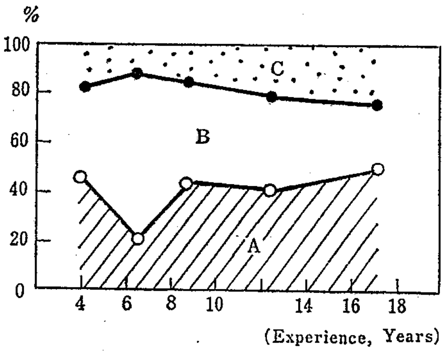
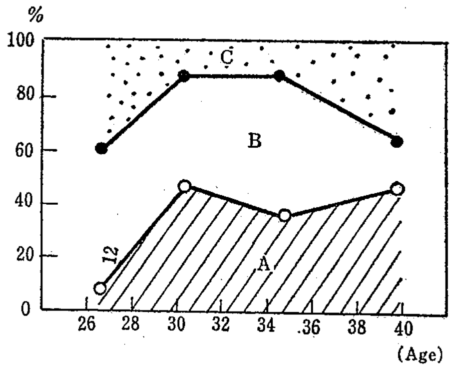


Figure 14. RELATIONSHIPS BETWEEN AGE AND UNDERSTANDINGS



unmistakably contributes more to better understanding than no experience at all. Figure 12 tells us that the experience does not make any difference after 4 years.

Figure 14 is meant to show the relationships between age and understandings. Some findings: junior falls in A and rises in C. Senior rises in A and C and tends to fall in B. The former implies that junior aged are somewhat inferior in understandings while the latter reveals a sharp devision between good and bad among the senior aged. However, we can hardly say that these findings are strong enough to establish any definite tendency. It would not be unfair to say that there is little relationships between age and degree of understanding as grouped into A, B, and C.

Figures 15 and 16 are showing distribution of A, B, and C groups by difference of educational background and kind of job, respectively. A slight inferiority is observed with graduates of the postwar senior high school (educational background) and electric apparatus (job). Degree of understanding does not seem affected to any meaningful extent either by educational background or kind of job. It may be concluded that the educational background and job differences do not make up influential factors on understanding any more than age and length of experience.

Finally, Figure 17 describes group-distribution of participants A, B, and C, according to the difference of their parent plants. Contrary to other factors so far examined, we can discern an orderly alignment between the origin of participants and their group-distribution. Hitachi, Sumida, and Senju plants were built in the 1920's and are the oldest among all the thermal plants under the management of the Tokyo Electric Power Company, Inc. Sumida has gone out of operation and Senju will soon be discontinued. Tsurumi No. 1 is a little younger than Senju being established during 1927 and 1936. Ushioda, as has been already introduced in the above, stands in-between the most up-to-date Chiba and rather obsolete Senju and Tsurumi No. 1. Tsurumi No. 2, which was built in 1955–1957, stands only next to Chiba in modernity of

Figure 15. RELATIONSHIPS BETWEEN EDUCATION AND UNDERSTANDINGS

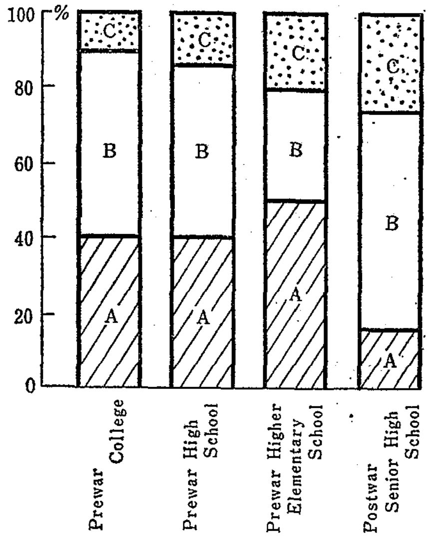
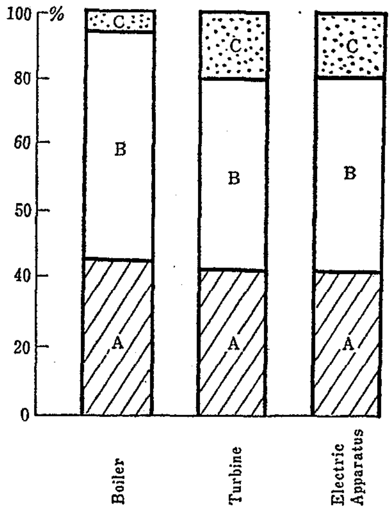


Figure 16. RELATIONSHIPS BETWEEN KINDS OF JOB AND UNDERSTANDINGS



facilities. In short, Tsurumi No. 2 is standing at the extreme end of modernity with Sumida and Hitachi on the opposite extreme; others are making a line in-between them in order of modernity.

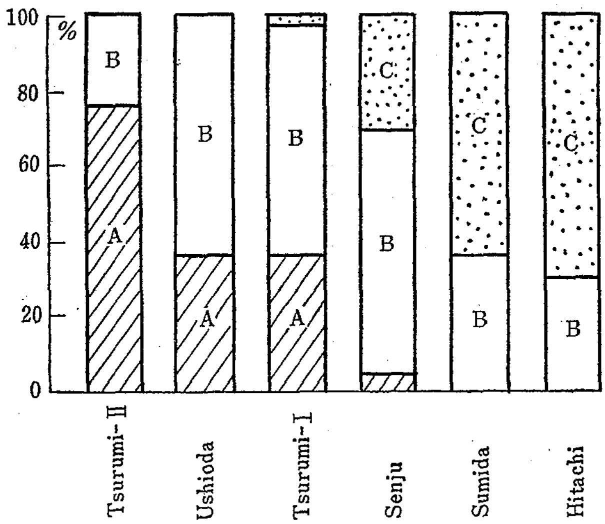
Participants coming from the most modern Tsurumi No. 2 are showing very high understanding with 74% of them being grouped into A and all the remainders (26%) into B. Those from Ushioda and Tsurumi No. 1, 23% to A and all the rest to B. None of those from the most obsolete Senju, Sumida, and Hitachi could enter A; they are all categorized into B and C.

Among five factors Age, Experience, Education, Job, and Parent Plant, only the last one has been discovered to have definite relationships with the degree of understanding, the determinant element being the modernity of the facilities there. While modernity of their parent plants awarded A to three-quarters of Tsurumi No. 2 people and B to the equal percentage of those from Ushioda and Tsurumi No. 1, the same proportion of people from Sumida and Hitachi were meted out with C.

Findings we have obtained so far will give us a definite suggestion or a guide-line for preparation of training programme meant for the participants' better adaptability to a given technique through removal of their psychological barriers. Our findings may be summarized as follows:

The labour-contents of the workers under the existing circumstances alone have bearings on the degree of their understanding new technique. The nearer are the labour-contents to a new technique, the higher becomes the degree of understanding of the latter. There exists a sort of continuity between the technique and its understanding.

Figure 17. RELATIONSHIPS BETWEEN PARENT PLANT AND UNDERSTANDINGS



If so, why should not this particular continuity be utilized for the adaptability-increase of the engineers and workers to a new technique? For instance, imagine we have to introduce a fairly high level technique into the area of extremely low standard of technique. We purposely go through a roundabout way by first bringing in a medium-level technique in-between that which needs to be ultimately given and the one that is in existence there. Let the people there be accustomed to such and adapted to the machinery. Once this is done, then, and only then, should the ultimate technique be ushered in.

This concept of the stage-by-stage adaptability-increase training might as well be applied for technical training offered by the industrially advanced countries on behalf of the trainees coming from less-developed countries. Its desirability seems obvious in view of the fact that not infrequently we see technical trainings are being conducted—though with limitation of time—heavily packed with concentrated practices and lessons which are beyond the easy reach of the trainees with such technical levels as they have obtained at home.

Slow it may seem but steady is the process and fruitful the result. Careful evaluation of the technical level and step-by-step elevation of it towards perfection is the lesson we may learn from our preceding study.