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A Socio-Technical Critique of Scientific Management[1]

The term "scientific management" begs two questions--what is "science" and what is "management." If, philosophically, the answers are plural and ambiguous, historically, the answer is singular and clear. Scientific management refers to the movement concerned with work measurement inaugurated by Frederick Taylor (1911) at the end of the first century of the first industrial revolution. Since then it has become the vast enterprise known as production or industrial engineering. Since then has also begun the second industrial revolution based on an information technology rather than simply an energy technology. With this second industrial revolution "management science," growing out of operation research, is becoming as intimately associated as scientific management has been with the first.

The distinction between the two has been well drawn by Russell Ackoff (1970):

> The first industrial revolution was made possible by the development of machines that were capable of replacing man and beast as sources of physical work. This substitution of machines for animals was called mechanization. The development of the relevant technology and its effective use in production processes required knowledge and understanding of the nature of physical work, i.e., what aspects of it

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could and could not be efficiently mechanized, and how men and machines could separately and collectively work together. At about the turn of this century, the need for mechanization attracted scientists and engineers from a variety of disciplines whose interests covered some aspects of the work process. As a result, work study was initiated. As knowledge and understanding were accumulated and systematized, those who were engaged in such research institutionalized and professionalized their efforts under the name of industrial (or production) engineering. Thus industrial engineering provided the intellectual fuel which powered the process of mechanization.

The second industrial revolution, which is still in its infancy, was started by two technological developments. The first involved the development of machines which could observe, or, in other words, which could convert the objective properties of objects and events into symbols representing those properties. Radar and sonar, developed in the United Kingdom in the late thirties, were such machines.

The second and more important technological development occurred in the mid-forties. Its product was the electronic digital computer, which can be described as a symbol-manipulating machine. These two developments made it possible to mechanize mental work which consists of observation, or symbol generation, and symbol manipulation. Mechanization of the particular type of mental work that we call decision making or control came to be known as automation.

In the first industrial revolution, the knowledge and understanding of the processes to be mechanized were called industrial engineering. Again, in the second industrial revolution, which began in the late thirties, scientists and engineers from a variety of disciplines rose to the challenge. The interdisciplinary activity which resulted came to be known as operational research or O.R. As operational research and the new

> technology developed, additional fields of related study emerged: these included information theory, decision theory, control theory, cybernetics and general systems theory. Here, as so often had been the case in the past, "engineering" preceded "science." Operational research workers adapted available scientific concepts, methods, techniques and tools to their tasks and improvised some new ones. Others were subsequently developed in the communication, decision, control and systems sciences.
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> Thus O.R. bears the same relation to the second industrial revolution as industrial engineering to the first. This explains why there was so much debate in the early days of O.R. about their similarities and their differences. At that time the distinction between the two revolutions was not clear.

Along with a number of others, the writer holds the view that the more complex, fast-changing, interdependent but uncertain world growing up in the wake of the second industrial revolution is rapidly rendering obsolete and maladaptive many of the values, organizational structures and work practices brought about by the first. In fact, something like their opposite seems to be required. This is nowhere more apparent than in the efforts of some of the most sophisticated firms in the advanced science-based industries to decentralize their operations, to debureaucratize their organizational form and to secure the involvement and commitment of their personnel at all levels by developing forms of participatory democracy.

Nevertheless, the classic efficiency cult, which Taylorism has come to symbolize, remains the prevailing value of contemporary industry. The majority of those pursuing the second industrial revolution are as much obsessed with it as were those who pursued the first, including many operational research workers who treat systems in much the same way as most industrial engineers treat jobs.[2] It will take some time before the minority, who have already learned to think in much wider terms, will secure an extensive hearing. By then much will have happened in the way of violence, alienation and poor performance that could have been avoided--if the world were a more rational place.

What then are the characteristics of the philosophy of work called scientific management? It has been summarized by my colleague, Louis Davis (1970/Vol. II, "The Coming Crisis for Production Management"), as follows:

- The man and his job are the essential building blocks of an organization; if the analyst gets these "right" (in some particular but unspecified way), then the organization will be correctly defined.
- Man is an extension of the machine, useful only for doing things that the machine cannot do.
- The men and their jobs--the individual building blocks--are to be glued together by supervisors who will absorb the uncertainties and variabilities that arise in the work situation. Furthermore, these supervisors need supervisors, and so on _ad infinitum_, until the enterprise is organized in a many-layered hierarchy. In bureaucratic organizations, the latter notion ultimately leads to situations in which a man can be called a "manager" solely on the grounds that he supervises a certain number of people, and without regard to the degree of judgment or decision-making responsibility such supervision requires.

[2]Among industrial engineers who thought along very different lines were James Gillespie in Britain and Adam Abruzzi in the United States.

• The organization is free to use any available social mechanism to enforce compliance and ensure its own stability.

• Job fractionation is a way of reducing the costs of carrying on the work by reducing the skill contribution of the individual who performs it. Man is simply an extension of the machine, and obviously, the more you simplify the machine (whether its living part or its nonliving part), the more you lower costs.

This whole conception is now often referred to by social scientists as the "machine theory of organization."

Industrial organizations built on these principles had their heyday in the mass production plants of the interwar period. Daniel Bell (1956) in his essay "Work and Its Discontents" sums up the pattern as follows:

> These three logics of size, time and hierarchy converge in that great achievement of industrial technology, the assembly line: the long parallel lines require huge shed space; the detailed breakdown of work imposes a set of mechanically paced and specified motions; the degree of coordination creates new technical, as well as social, hierarchies.

There is less need in the present context to elaborate on the extent to which the concentration, atomization and control of work was carried than to point to the nature of the penalty paid for the benefits gained. If the benefits gained included more productivity at less cost in the short run within the enterprise itself, the penalties paid included more alienation in the longer run, which spread into the larger society only to react back on the more immediate economic sphere. For some time this was masked in the classic forms of industrial struggle as organized labor sought better conditions for the mass of semiskilled and unskilled workers--more pay, shorter hours, improved amenities, etc. After a period of initial resistance, unions began to learn how to use work-study as a bargaining method in their own interest. This was not a matter inherently related to ownership of the means of production. Lenin admired Taylor and entertained high hopes of what scientific management might do for industry in the Soviet Union.

But as the first signs of the affluent society began to appear, as the Great Depression faded into the background and a new level of economic well-being established itself after World War II, it became evident that something of another kind was wrong, whatever the amount of take-home pay or even security of employment. A first glimpse of what this might be had been obtained in the Hawthorne Experiments carried out by Elton Mayo's followers in Western Electric's plants in the Chicago area at the height of the scientific management wave (Roethlisberger and Dickson, 1939). These were the first extensive studies made in industry by social scientists as distinct from psychologists, concerned with more limited psychophysical problems. They led to the curious and belated discovery that workers were human even in the workplace and that they responded to being treated as such. This led to the rise of the human relations movement which, in sophistication of theory and method, has reached a degree of elaboration as great as scientific management, though it has never matched it in extensiveness of application.

The direction of development taken by the human relations movement was one which concentrated exclusively on the enterprise as a social system. The technology was not considered. Workers were to be treated better but their jobs would remain the same--similarly with supervisors or, for that matter, managers themselves. As Peter Drucker (1952) put it:

> It has been fashionable of late, particularly in the "human relations" school, to assume that the actual job, its technology, and its mechanical and physical requirements are relatively unimportant compared to the social and psychological situation of men at work.

What this statement means is that nobody thought the job itself could be changed. It was regarded as invariant. The technological imperative was taken for granted. It was logical, therefore, to concentrate attention on what were considered, however mistakenly, to be the only variable aspects.

The need to pay attention to the social and psychological aspects as a matter of practical personnel policy was generally recognized when full employment conditions were established after World War II in countries such as Britain. Full employment, more than anything else, gave rise to personnel management. The "stick" was unavailable; the "carrots" on offer were often indigestible and always limited. The game of economic rewards continued to be played according to the rules of wage-bargaining between management and labor, where expectations of a fair deal were based on the power balance between the two parties. The recent history of productivity bargaining shows how much it is still played this way. But wage matters apart, attempts were made to set up good relations between all groups and types of personnel in the company, most especially between management and workers. So far as greater loyalty and trust could be established, labor turnover would be reduced and industrial disputes made less likely.

As the management/worker interface was mediated by the foreman, a massive movement took place in supervisory training. How far was person-centered supervision better than task-centered supervision, two-way communication better than one-way communication, persuasion better than coercion, a democratic style of leadership better than an authoritarian style of leadership? How could one change supervisors from one way of behaving to the other? It was soon known that it was of no avail to change the attitudes of foremen if those of management did not change as well (Likert, 1958). So began a far-reaching movement in management training, which later broadened first into management and then into organizational "development" as more of the complex interdependencies and dimensions of the enterprise as a social system were taken into account (Bennis, 1966a, 1966b).

Certain beliefs about the nature of humanity and its basic needs and motivations in the work setting began to gain currency that were the opposite of those held in the scientific management school. Abraham Maslow (1954) introduced his need hierarchy, which postulated that as the more primitive needs for food, sex and security became satisfied, higher needs concerned with group belongingness, self-esteem and self-fulfillment would become more salient. Emphasizing that this would be so even in the workplace, Douglas McGregor (1960) contrasted two models of "industrial man" that he called Theory X and Theory Y. The first represented the traditional management view of workers which had grown up with the first industrial revolution. They were fundamentally "no-goods"--lazy, irresponsible, selfish, etc. They therefore required external control. The second model represented an emergent view: that workers were ordinary, good human beings at work as much as they were at home or as citizens.

They had a need for achievement, to take responsibility and to be both creative themselves and to take cognizance of others. They were therefore capable of internal control. Basically, they were self-motivating and self-supervising.

Later, we shall return to a facet of utmost significance--that these views made their impact at a time when advanced industrial societies, especially the United States, were becoming not only more affluent but were already well into the second industrial revolution with the very different tasks and roles that the newer technologies were beginning to create. These roles demand involvement and commitment, initiative and the good use of discretion at the bottom of the enterprise no less than in the middle and at the top. This connection was not made by anyone within the human relations approach.[3] Nevertheless, a view of the human side of the enterprise developed that was incompatible with the machine theory of organization. But no one attempted to alter the character of the jobs themselves, which continued to be designed according to the principles of scientific management. In the United States social science attention shifted to the problems of higher management with its increasing needs for flexibility and adaptability in facing change and uncertainty (Trist, 1968). While at this level democratic social climates with transactional forms of relationship between superior and subordinate were tried out, as being best suited to the ends of the enterprise, for the same economic reasons, the shop floor continued to be set up and operated in terms of the values and concepts of the first industrial revolution, elaborated and refined by the principles of scientific management.

Quite early in the post World War II period, 1948-51, the Tavistock Institute undertook an intensive action research study of the London factories of the Glacier Metal

[3]Among British social scientists, however, the connection between technology and organization was central for such writers as Woodward (1958) and Burns and Stalker (1961).

Company (Jaques, 1951/Vol. I). Concerned with group relations at all levels, it led to the establishment of a new type of representative structure. Enlightened personnel policies and wage practices were implemented with unusual thoroughness. Yet the underlying alienation of the ordinary worker persisted. The "split at the bottom of the executive chain" remained. The only major factor that had not undergone change was the task or work organization deriving from the technology. This had remained in the old modality. What would happen if this modality itself were changed?

An opportunity to begin finding this out arose at the same time in the then recently nationalized coal industry, where strikes, labor turnover and absenteeism were persisting unabated despite the changeover to public ownership and the introduction of many improvements in pay and working conditions. In the first of what turned out to be a very long series of researches, the writer and a colleague, a former miner, were able to observe at a pit in the Yorkshire coalfield what happened when the method of work organization was changed from the traditional form of job-breakdown to one in which autonomous groups interchanged tasks and took responsibility for the production cycle as a whole. The new groups were formed by the men themselves (Trist and Bamforth, 1951/Vol. II, "The Stress of Isolated Dependence: The Filling Shift in the Semi-Mechanized Longwall Three-Shift Mining Cycle"). More extensive experiments using what became known as the composite method were made in East Midland Division between 1951 and 1953, initiated by V.W. Sheppard (1951), who was later to become the National Coal Board's Director General for Production and eventually Deputy Chairman. The gains in productivity and job satisfaction were both substantial, the former being up between 20 and 30 percent for less cost and the latter, apart from expressions of opinion, manifesting itself in decreased absenteeism, negligible labor turnover and an improved health record (Wilson et al., 1951). During further studies in Durham Division, 1954-58, an opportunity arose to carry out a crucial experiment in which the performance of two identical coal faces, using an identical longwall technology--one organized in the conventional and the other in the composite way--were monitored over a period of two years. The composite face was superior in all respects (Trist et al., 1963).

Meanwhile, another Tavistock research worker, A.K. Rice, had applied composite principles in another industry in another country--the textile industry in Ahmedabad, India (Rice, 1958/Vol. II, "Producivity and Social Organization: An Indian Automated Weaving Shed"; Miller, Vol. II, The Ahmedabad Experiment Revisited: Work Organization in an Indian Weaving Shed 1953-70"). As soon as the idea of a group of workers becoming responsible for a group of looms was mentioned in discussing the experimental reorganization of an automatic loom shed, the workers spontaneously took up the idea, returning the next day with a scheme which was accepted and immediately tried out. Early success was followed by vicissitudes due to many factors which were investigated, but, thereafter, a steady state of significantly improved performance was attained. Higher wages were earned and the internally led loom groups, which carried out their own maintenance, offered "careers" from less to more skilled roles, while Hindus and Moslems worked together. The system spread to ordinary looms. Though supported by the local trade union, it came under political attack. Agitators from all parts of the country were brought into Ahmedabad by the Indian Communist Party which, like communist parties elsewhere, opposed innovation that it could not fit into its "operational model"--though Marx might have been more appreciative judging from his neglected observations on machines and their relations to workers. Members of the work teams and their families were threatened with physical violence if they continued the new system. Attempts were made to set the Hindu and Moslem workers against each other. The attack failed. The workers stuck to a system that was very largely their own creation and that enabled them to enjoy a quality of work life as well as a level of income which they had not previously known.

While their own change experiments were proceeding, the Tavistock workers were able to ascertain that sporadic developments along the same lines had taken place in the telephone industry in Sweden, in the building industry in Holland and in the appliance manufacture and chemicals industry in the United States. There was another way to organize productive work than the prevailing way. There was *organizational choice*.

In the United States, recognition grew that quantified external control and job fractionation had been carried too far, and job enlargement received extensive trial (Walker and Guest, 1952). A distinction was made between extrinsic job satisfaction (which included the pay packet) and intrinsic satisfaction deriving from the quality of the job itself. This was recognized as a major factor affecting motivation (Hertzberg et al., 1959). But such recognition implied altering the way jobs were <u>designed</u> (Davis, 1955, 1957). This meant changing the technological organization, the system which the human relations school had left intact and which the scientific management school had continued to design according to the atomistic ideology that had characterized 19th-century science.

From the beginning, the Tavistock workers had felt that a new unit of analysis was required. This led the writer to introduce the concept of the *socio-technical system* (Trist, 1950/Vol. II, "Socio-Technical Ideas at the End of the '70s"). The problem was neither that of simply "adjusting" people to technology nor technology to people but of organizing the interface so that the best match could be obtained between them. Only the socio-technical whole could effectively be "optimized." In the limit, the socio-technical whole comprised the enterprise as a whole--in relation to its environment--as well as its primary work groups and intervening subsystems (Emery and Trist, 1960). It was necessary to change the basic model in which organization theory had been conceived.

Using Sommerhoff's (1950) theory of directive correlation, Emery (1966) has formulated the matching process in terms of joint optimization:

> Where the achievement of an objective is dependent upon *independent* but *correlative* systems, then it is impossible to optimise for overall performance without seeking to jointly *optimise* these correlative systems.
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> Any attempts to optimise for one without due regard to the other will lead to sub-optimal overall performance, so even if an effort is made in an industrial situation to follow the traditional pattern, i.e., to optimise the technical system and hope the social system will somehow sort itself out, then sub-optimisation is certain to result. This is also the case when attempting to optimise each system, but independently, ignoring interaction effects.
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> It is important to remember that this principle applies where the systems are *independent* but *correlative*. ... It does not necessarily apply where one system is, in fact, a *part of another*, e.g., a sales section of a company is part of a social system

> governed by the same laws as the rest of the social system. Where this is the case ... the chain may be seized by the key link and the rest follows. Socio-technical systems, however, are composed of two distinct systems which, although correlative, are governed by different laws.

Pulling together the findings of a number of investigations, he has offered a set of general socio-technical principles for job design (Emery, 1963/Vol. II, "Socio-Technical Unit Operations Analysis"). As these go to the heart of the matter they will be quoted in full:

> The judgment that it is possible to redesign jobs in this way rests upon the evidence that men have requirements of their work other than those usually specified in a contract of employment (i.e., other than wages, hours, safety, security of tenure, etc.). The following list represents at least some of the general psychological requirements that pertain to the content of a job (to what a person is called upon to carry out in his job from hour to hour and from year to year):
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> > The need for the content of a job to be reasonably demanding in terms other than sheer endurance and yet providing a minimum of variety (not necessarily novelty).
> >
> > The need for being able to learn on the job and go on learning. Again, it is a question of neither too much nor too little.

The need for some minimal degree of social support and recognition in the workplace.

The need to be able to relate what he does and what he produces and to his social life.

The need to feel that the job leads to some sort of desirable future (not necessarily promotion).

These requirements are obviously not confined to any one level of employment. Nor is it possible to meet these requirements in the same way in all work settings or for all kinds of people. Complicating matters further is the fact that these needs cannot always be judged from conscious expression. Like any general psychological requirements, they are subject to a wide range of vicissitudes. Thus, where there is no expectation that any of the jobs open to a person will offer much chance of learning, that person will soon learn to "forget" such requirements.

As already indicated, these requirements, however true they may be, are too general to serve as principles for job redesign. For this purpose they need to be linked to the objective characteristics of industrial jobs. The following is the preliminary set of such principles with which these studies started. They represent the best we were able to achieve by way of generalising upon existing findings. They are not, we hope, final:

At the Level of the Individual

Optimum variety of tasks within the job. Too much variety can be inefficient for training and production as well as frustrating for the worker. However, too little can be conducive to boredom or fatigue. The optimum level would be that which allows the operator to take a rest from a high level of attention or effort or a demanding activity while working at another and, conversely allow him to stretch himself and his capacities after a period of routine activity.

A meaningful pattern of tasks that gives to each job a semblance of a single overall task. The tasks should be such that although involving different levels or attention, degrees of effort, or kinds of skill, they are interdependent; that is, carrying out one task makes it easier to get on with the next or gives a better end result to the overall task. Given such a pattern, the worker can help to find a method of working suitable to his requirements and can more easily relate his job to that of others.

Optimum length of work cycle. Too short a cycle means too much finishing and starting; too long a cycle makes it difficult to build up a rhythm of work.

Some scope for setting standards of quantity and quality of production and a suitable feedback of knowledge of results. Minimum standards generally have to be set by management to determine whether a worker is sufficiently trained, skilled or careful to hold the job. Workers are more likely to accept responsibility for higher standards if they have some freedom in setting them and are more likely to learn from the job if there is feedback. They can neither effectively set standards nor learn if there is not a quick enough feedback of knowledge of results.

The inclusion in the job of some of the auxiliary and preparatory tasks. The worker cannot and will not accept responsibility for matters outside his control. Insofar as the preceding criteria are met then the inclusion of such "boundary tasks" will extend the scope of the workers' responsibility and make for involvement in the job.

The tasks included in the job should include some degree of care, skill, knowledge or effort that is worthy of respect in the community.

The job should make some perceivable contribution to the utility of the product for the consumer.

At Group Level

Providing for "interlocking" tasks, job rotation or physical proximity where there is a necessary interdependence of jobs (for technical or psychological reasons). At a minimum this helps to sustain communication and to create mutual understanding between workers whose tasks are interdependent and thus lessens friction, recriminations and "scape-goating." At best, this procedure will help to create work groups that enforce standards of co-operation and mutual help.

Providing for interlocking tasks, job rotation or physical proximity where the individual jobs entail a relatively high degree of stress. Stress can arise form apparently simple things such as physical activity, concentration, noise or isolation if these persist for long periods. Left to their own devices, people will become habituated but the effects of the stress will tend to be reflected in more mistakes, accidents and the like. Communication with others in a similar plight tends to lessen the strain.

Providing for interlocking tasks, job rotation or physical proximity where the individual jobs do not make an obvious perceivable contribution to the utility of the end product.

Where a number of jobs are linked together by interlocking tasks or job rotation they should as a group:

have some semblance of an overall task which makes a contribution to the utility of the product

have some scope for setting standards and receiving knowledge of results

have some control over the "boundary tasks."

Over Extended Social and Temporal Units

Providing for channels of communication so that the minimum requirement of the workers can be fed into the design of new jobs at an early stage.

Providing for channels of promotion to foreman rank which are sanctioned by the workers.

It is clearly implied in this list of principles that the redesigning of jobs may lead beyond the individual jobs to the organisation of groups of workers and beyond into at least the organisation of support services (such as maintenance). There is reason to believe that the implications are even wider and that they will in any organisation be judged to be much wider and reacted to accordingly.

Since these principles were formulated, a good deal of experience has been gained with more advanced technologies that depend on processes of continuous production and a high level of automation and computerization. As a result, a nine-step analytical model for socio-technical inquiry has been gradually taking shape (Emery, 1967). Though never formalized, the model may be summarized as follows:

1. An initial scanning is made of all the main aspects--technical and social--of the *selected target system*, i.e., the department or plant to be studied.

2. The *unit operations* are then identified, i.e., the transformations (changes of state) of the material or product which take place in the target system, whether carried out by workers or machines.

3. An attempt is then made to discover the *key process variances* and their interrelations. A variance is any deviation from a standard or specification. A variance is key if it significantly affects

   • the quantity of production

   • the quality of production

   • the operating or *social* costs of production.

4. A table of variance control is then drawn up to *ascertain how far the key variances are controlled by the social system*--the workers, supervisors and

managers concerned. Some of the most important variances may be imported or exported. Investigation of this is one of the most critical steps. Another is to check *how far existing work roles satisfy the six basic psychological requirements*. Attention is then paid to ancillary activities, spatiotemporal relationships, the flexibility of job boundaries and the payment system.

5. A separate inquiry is made into the *workers' perception of their roles*--and of role possibilities as well as constraining factors. Here is a mine of unsuspected knowledge as much as of unsuspected feeling.

6. So far, concern has focused on the target system. It now changes to *neighboring systems*, beginning with the support or *maintenance system*.

7. Inquiry continues into the boundary-crossing systems on the input and the output side, i.e., the *supplier and user systems* which comprise adjacent departments. How do the structures of these units affect the target system and in what state are relations across these interfaces?

8. The target system and its immediate neighbors must now be considered in the context of the *general management system* of the plant or enterprise, particularly as regards the effects of *general policies* or *development plans either technical or social.*

9. Suggestions for change may arise at any point in the analysis, which proceeds by a recycling rather than a strictly sequential procedure, but only when all stages have been completed does it become possible to formulate *redesign proposals* for the target system or to take up wider implications.

This analytical model, which uses an open systems approach similar to that of Katz and Kahn (1966), is not intended as a procedure for the sole use of research workers. It is intended also for operating people in plants where management and workers together have decided to undertake change in which explicit use will be made of socio-technical principles. It has therefore been prepared as a training method. Recently, Davis and the writer, along with other colleagues, held the first university course in the method at the Graduate School of Business Administration of the University of California, Los Angeles. Some 20 managers, industrial engineers and personnel people attended for an intensive period of three weeks. They were drawn from Alcan's smelting plants in Quebec Province, Canada, where socio-technical experiments have been in progress for some two-and-a-half years with the operators and the union now thoroughly involved (Davis and Trist, 1969).

Though toward the end of the 1950s the Tavistock research group had extended its inquiries to examples of the more advanced technologies, these had remained descriptive studies. No further opportunities to conduct operational field experiments arose in a British setting. The next major developments took place in Norway in conjunction with what has become known as the Norwegian Industrial Democracy Projects (Thorsrud and Emery, 1964). This has given a new dimension to socio-technical studies, relating them to central questions of value change as the era of the post-industrial society is brought nearer by the technologies of the second industrial revolution.

The project began in 1961 and is still proceeding. It grew out of a crisis between the Norwegian Confederation of Employers and the Norwegian Confederation of Labor over a sudden increase in the demand for workers' representation on boards of management proposed as a way of reducing alienation and increasing productivity. What is remarkable is that the two Confederations (later joined by the Government) should have requested the assistance of social scientists in order to gain a better understanding of what ordinarily would have been treated as a political problem. But, having helped establish a group, directed by Einar Thorsrud, which had earned their trust, they requested it to undertake research relevant to their problem. Through the ramifications of the project, the group concerned has had to move from Trondheim to Oslo where it now comprises the Institutes of Work Psychology. From the beginning, it drew on the Tavistock's Human Resources Centre as a collaborating organization. Another remarkable feature of the project has been the extent to which research plans have been drawn up in conjunction with representatives of the sponsoring Confederations. This was a necessary condition for success, since the objective could not be limited to undertaking isolated socio-technical experiments. It was, first, to secure an understanding in the leadership of both sides of Norwegian industry of the relevance to problems at the national level of a socio-technical philosophy of work; and, thence, to establish the conditions which would allow this philosophy to diffuse through Norwegian industry at large.

The first phase of the project consisted of a field study of what actually happened in the five major concerns where workers were represented on the boards. These were either government owned or partly government owned enterprises obliged by law to have workers' representatives. The results showed that very little happened except at the symbolic and ceremonial level. There was no increase in participation by the rank and file, no decrease in work alienation, no increase in productivity. The overall state of industrial relations being stable with a stable framework of political democracy, little was added simply by adding a workers' representative to the board of directors. These results, which were compared with experiences in other countries, were widely discussed in both Confederations and in the press. These discussions opened the way for the second phase of the project, which was to search out ways for securing improved conditions for personal participation in a worker's immediate setting as constituting "a different and perhaps more important basis for the democratization of the workplace than the formal systems of representation."

This led to the idea of socio-technical experiments in selected plants in key industries, which, if successful, could serve as demonstration models for diffusion purposes. The selections were made by the members of the two Confederations serving on the research committee in consultation with sector committees of the industries concerned. No pains were spared in developing at all levels an understanding of, and in securing an acceptance of, the experiments in the plants proposed, which had to be respected organizations carrying weight and which, moreover, had to be seen as foreshadowing the future direction of Norwegian industrial development without being too far out. To obtain this breadth and depth of sanctioning and centrality of societal positioning was regarded as essential. Its absence in other contexts had prevented the spreading of proven innovations.

The first experiment was carried out in the metal-working industry, a sector regarded as critical but requiring considerable rehabilitation. A rather dilapidated wiredrawing plant in a large engineering concern was chosen on the grounds that if improvements could be brought about here, they could be brought about anywhere. Productivity increased so much that the experiment was suspended. The workers concerned had begun to take home pay packets in excess of the most skilled workers in the plant. A very large problem had now to be sorted out. If this experiment confirmed earlier findings regarding what could be accomplished when alienation is reduced, it showed up for the first time the magnitude of the constraining forces lying in the wage structures and agreements negotiated according to the norms of the prevailing work culture and accumulating historically. The difficulty of changing such structures, in considerable measure, accounted for the failure of earlier pilot experiments to spread out through the system.

The second experiment was in the pulp and paper industry, also regarded as a critical sector, but where the problem was not so much to upgrade performance with old technologies as to gain control over new. A sophisticated chemical plant was selected where the basic work was information-handling--the core task in the technologies of the second industrial revolution. The requisite skills are perceptual and conceptual; the requisite work organization is one capable of handling the complex information flows on which controlling the process depends. To do this requires immense flexibility and capability for self-regulation. In the experimental plant a number of the key process variances were not being controlled by the social system nor had some of the most important variances been identified. The research team had to engage those concerned in evolving a form of organization that brought as many of the variances as possible under the control of the primary work groups. After much resistance and many setbacks, a process of continuous learning began to establish and to maintain itself as improvements were effected first in one area, then in another.

The model was established of an "action group" consisting of operators actively using supervisors, specialists and managers as resources--rather than passively responding to them simply as bosses--in order to fashion an optimum work organization for a new technology as they were learning the know-how of its operation. This model was now taken up by Norskhydro, the largest enterprise in Norway, which manufactures fertilizers and other chemicals for the world market. The model was first used to refashion an old plant, then to develop the entire organization and operating procedures for a new one (Thorsrud, 1968).

The success of the Norsk Hydro experiments has been widely publicized throughout Scandinavia. It marked the beginning of the third phase of the project concerned with the diffusion process itself. In Norway, the Joint Committee which originally sponsored the project was transformed into a National Participation Council and a new Parliamentary Commission on Industrial Democracy was formed. In Sweden similar developments have recently taken place at the national level, but it will be some time before a critical mass of concrete experience with the new methods can build up. The situation is similar in Denmark. Meanwhile, in Norway, the most significant recent developments have taken place in the shipping industry in the manning of bulk carriers (Herbst, 1969/Vol. II, "A Learning Organization in Practice: M/S Balao").

Undoubtedly there are features in the culture of the Scandinavian countries and in their situation, Norway most particularly, which have enabled them to act as the laboratory of the world in developing a new concept of industrial democracy based on socio-technical theory. In large countries which are more authoritarian, where the first industrial revolution has left a deeper imprint or where the culture is more fragmented, much greater difficulties are to be expected. In Britain, there are signs of the trail being taken up again by specific but important firms. The refining side of Shell, for example, invited the Tavistock Institute to assist it in developing a new management philosophy based on the principle of joint optimization (Shell Refining Co., 1966; Hill, 1971; Hill and Emery, Vol. II, "Toward a New Philosophy of Management"). In Ireland, the national transport undertaking (CIE) undertook an extensive project (van Beinum, 1966). Sporadic developments continue here and there in the United States (Seashore and Bowers, 1963; Myers, 1964).

The underlying change which has taken place is that in the science-based industries of the second industrial revolution, workers are not workers in the sense of the first industrial revolution. They are no longer embedded in the technology, contributing their energy to it or even their manipulative skill, but they are outside it, handling information from it and themselves becoming sources of information critical for its management. This change of position and role makes them, in fact, managers, different in degree but not in kind from those who traditionally have carried this title. For the task of management is the regulation of systems and the function of managerial intervention (decision) to establish control over the boundary conditions. Such is the type of activity in which workers now primarily engage, as fact-finders, interpreters, diagnosticians, judges, adjusters and change agents; whatever else they do is secondary. In Jaques's (1956, 1960) terms, the <u>prescribed</u> part of their role has become minimal. The "program" is in the machine; the <u>discretionary</u> part has become maximal--the reason for the workers. presence is to assess the performance of the program and, if necessary, to change it, either themselves or in conjunction with others at higher levels. No longer is there "a split at the bottom of the executive chain" that separates managers and managed. Everyone is now on the same side of the "great divide," and whatever fences there may still be on the common side would seem best kept low. A general change is, in consequence, taking place in all role relationships in the enterprise. This is the underlying reason for the bureaucratic model being experienced as obsolete and maladaptive, and also for a possible new role beginning to emerge for trade unions (van Beinum, 1966).

To maintain in a steady state the intricate interdependences on which the science-based industries depend requires commitment to, and involvement in, their work from the workers on the shop floor (those who are left) as much as from anyone higher up (and there are fewer of these at intermediate levels). External supervision may correct errors that have been made, but only internal supervision can prevent their occurrence. The amount of error which capital-intensive continuous production plants can tolerate is small compared with plants based on technologies which are labor-intensive and discontinuous. There is a straight economic reason for this; work-stoppages have become too costly, whether they result from machine breakdown due to incompetence or carelessness or from labor trouble due to bad internal relations or external pressures. But if anything at all has become clear about automated plants it is that they do not work automatically. They are the creation of those who man them as much as of those who build them; design continues as operation commences and operational experience informs further design which, from the beginning, has to be developed as a socio-technical process. Moreover, this socio-technical creativeness must be maintained because the change-rate is both rapid and continuous. The autonomous work group setting out on an expedition of learning and innovation from which there is no return would appear to be the organizational paradigm that matches and that is "directively correlated" with the information technology. The advance of technology itself has reversed the world of Frederick Taylor.

Though a great deal of industry does not yet belong to the information technology and though some of it will never belong, the part that does has already become the "leading part." Its influence on the rest may be expected to increase. Moreover, in all contexts there is organizational choice. This is likely to be more frequently exercised in the direction of the new paradigm now that the old paradigm is no longer taken to be a law of nature. Marshal McLuhan (1964) seems to be right in thinking that automation means "learning a living."

The transition to a new concept of the world of work may be slow, unpleasant and difficult, but intolerance (whether in the form of rebellion or dropping out) of narrow and overprescribed jobs is mounting. The contemporary malaise deplored by the "silent majority" may itself be a main force which will hasten beneficial change, for the technological excuse for any job to be inhuman rather than human is rapidly diminishing. Those who wish to be "human" will have more of a chance in the future than many have had in the past.

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