On to optimizeRice: Productivity and

A.K. Rice

Productivity and Social Organization

An Indian Automated Weaving Shed (1)

The tendency to treat the technological and social organizations of an industrial unit as separate systems has sometimes led to difficulty when technological change has been introduced without adequate appreciation of its social repercussions. In their account of the Hawthorne Studies, Roethlisberger and Dickson (1939) described an industrial organization as a social system and drew attention to the interdependence of the technological and human organizations. In the human organization they included the formal and informal structures of groups. Trist and Bamforth (1951) showed that the introduction of the three-shift longwall cycle into British coal-mining resulted in the breakdown of an established social system and the mformation of maladaptive mechanisms as defenses against the social and psychological consequences of the technological organization. Rice and Trist (1952), investigating change in labor turnover, used a method of analysis which suggested that an understanding of the whole system--the socio-technical system, containing both technical and social dimensions--was necessary to explain both the kind and the direction of change in labor turnover when either technological or social change occurred. [1]

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(1) This paper, condensed from "*Productivity and Social Organization in a Indian Weaving Shed:* An Examination of the Socio-Technical Systems of an Experimental Automatic Loomshed." *Human Relations:* 6:297-329, 1953, describes Rice's first experiment in designing a form of work organization to optimize the technical and social dimensions.

This paper (2) describes a preliminary analysis of the socio-technical system of an experimental automatic loom shed, weaving cotton cloth, on the basis of which the methods of working were reorganized and an increase in productivity achieved. The analysis was made during recent work by the Tavistock Institute in the Ahmedabad Manufacturing and Calico Printing company Limited in Ahmedabad, India. The company, known more familiarly as the "Calico Mills," manufactures finished cloth from raw cotton and employs approximately 8,000 workers. The author visited the mills in the capacity of professional consultant. The purpose of his visit, which was exploratory, was to allow both the company and the Institute to discover whether it was possible to establish a collaborative relationship in which the Institute could make a contribution to the solution of the general social and production problems of the mills.

The analysis was made in collaboration with a development group in which the author worked with the chairman, mill manager and works manager of the company. (The works manager was the direct executive subordinate of the mill manager, who reported directly to the chairman. The works manager also acted, however, as technical staff officer to the chairman.) The members of this group collaborated closely, working as a group, in pairs or singly as the situation demanded, until each was satisfied of the validity of the analysis. They reported as a group to the other members of senior management at all stages. The decision to initiate the reorganization was taken by the chairman at a meeting which was attended by all senior managers. At that meeting the weaving master of the mill concerned was called in. He listened

(2) Trist, who collaborated with the author in the writing of this paper, first used the concept of socio-technical system when studying the socio-psychological and technical problems of the introduction of increased mechanization in coal-mining. The term has since been extended to designate a general field of study concerned with the interrelations of the technical and socio-psychological organizations of production systems.

with evident enthusiasm to the proposals and began at once to produce from his own experience arguments in their favor. The works manager, as the senior executive responsible for the experimental loom shed, then discussed the proposals with the top supervisor of the shed. Thereafter, the supervisors and workers in the loom shed took over the proposals as their own; within a few hours, to the surprise of management, the workers had organized their own working groups. The chairman, mill manager, works manager and the author did not attend any of the discussions with supervisors or workers, nor did they visit the loom shed again until the reorganization had been implemented. The author returned to London on the seventh day of the experimental period and the results reported in this paper have been sent to him by the works manager. The paper was, however, discussed in detail with the chairman of the company, Gautam Sarabhai, when he was in England. His help with the paper and his permission to publish it are gratefully acknowledged.

The paper is in three parts. First, there is a brief description of the loom shed before reorganization; second, this organization is analyzed and the reorganization described; and finally, the results of the reorganization are reported.

Experimental Automatic Loom Shed

Activities of the Loom Shed

Automatic looms had been introduced into one of the mills in June, 1952. By March 1953, an experimental shed containing 224 looms had been set up. It was designed

eventually to hold 304 looms but, at the time of reorganization, a part of the shed was still under construction.

The operations of automatic weaving are carried out by *bobbins* containing *weft* yarn (threads across the length of the cloth) and *beams* containing *warp* yarn (threads along the length of the cloth). An automatic loom is prepared for weaving by *loading*. A beam is *gated* into brackets at the back of a loom, and each warp thread is passed through the eye of a *heald*, then through a *reed*, or comb, to keep it in place and is finally connected to a roller on the front of the loom which takes the woven cloth. A bobbin containing weft yarn is placed in a *shuttle* from which it is automatically ejected when it is empty or when the weft thread breaks. Empty bobbins are automatically replaced by full bobbins stored in a *battery*. When the loom is weaving, the shuttle is knocked backward and forward through a *shed* formed by the separation of the warp threads by the rise of some healds and the fall of others. As the shuttle travels through the shed it leaves behind it a weft thread which is wound from the bobbin within the shuttle. Each weft thread so inserted is banged into place by the reed. The weaving ceases when the warp yarn on the beam has all been converted into cloth on the roller. The loom is then *unloaded*, the finished cloth is taken from the loom (this may occur at intervals during weaving by cutting off the finished cloth) and the empty beam is removed. During weaving, stops of short duration occur whenever a warp thread breaks. A loom is restarted when the broken ends have been joined together (knotted). The looms are fitted with mechanical stops which halt the loom automatically whenever a warp thread breaks.

The activities of a single loom are, therefore, cyclic--load, weave, unload. But since weaving time (including stops for yarn breaks) always greatly exceeds loading and

unloading time, the total activities of a loom shed are continuous, only a small proportion of the looms being stopped for loading and unloading at any one time. During stops for the loading and unloading of looms, general loom maintenance, automatic device maintenance, tuning and oiling activities are carried out, and all accumulated fluff is removed from under the loom.

The length of yarn which can be wound on a beam or on a bobbin depends on the size of the beam or bobbin and on the fineness of the yarn (the count)--the finer the yarn, the higher the count. The kind of cloth woven (the sort) depends on the count of the yarn and on the number of threads to the inch in both warp and weft. The rate of weaving depends, therefore, on the speed and continuity of loom run and on the sort.

Under the climatic conditions in Ahmedabad, relative humidity in the loom shed has to be artificially maintained at 80 to 85 percent to enable yarn to stand up to the strain put on it in the weaving process. For this purpose, a humidification plant is installed which humidifies the whole shed.

Two eight-hour shifts were worked, the day shift from 7.00 a.m. to 3.30 p.m. and the night shift from 3.30 p.m. to midnight, with a half-hour break each in midshift.

Productivity is measured by two figures--efficiency and damage. Efficiency is the number of *picks* (weft threads) inserted in any shift expressed as a percentage of the number of picks which would have been inserted had the loom run continuously for the whole shift. No allowance is made for loading, unloading or for any other stops. Damage is the percentage of cloth not accepted as of standard quality by the inspectors and viewers after weaving. The higher the efficiency and the lower the damage, the greater the productivity.

Occupational Roles and Tasks

Current British and American practice had been followed in the organization of the shed. The total task of weaving had been broken down into component operations and each component was performed by different workers. The number of workers allocated to the various tasks had been based upon British, American and Japanese standards--the looms were of Japanese manufacture--modified by the time studies of work under Indian conditions and based on yarn breakage rates existing in the mill at the time of installation. The experimental shed started working when 12 looms had been installed. Neither management nor workers had had experience of modern working methods with automatic looms. During the first eight months looms were brought into production as they were erected and workers trained to use them. By March 1953, relatively stable conditions had been established with the 224 looms installed, and further loom erection had been halted pending the completion of the building.

At this point, the deployment of workers, with the number of workers per shift in each occupational role shown in parentheses, was as follows. A top supervisor was in overall charge of the two shifts. Responsible to him, on each shift, was a works supervisor. His command comprised all the shift workers except the humidification fitter (1), who reported directly to the top supervisor. Jobbers, (2) whose task was mainly loom maintenance and adjustment, not only supervised the assistant jobbers (2) but also exercised some directive authority over all other workers. These included: the feeler-motion maintenance fitter (1); weavers (8); gaters (2) who replaced empty beams; battery fillers (5) maintaining the supply of full bobbins; oiler (1); smash-hands (3) who joined broken ends of yarn after a major breakage and who were in training as weavers; cloth carrier (1); bobbin carriers (2); and sweeper (1). This

complement of workers was considered to be adequate for up to 240 looms.

It is evident that, although all the tasks of the shed were interdependent, only the jobbers and assistant jobbers had any form of stable work group structure and that the other workers formed an aggregate of individuals some of whom were virtually independent of each other. The jobbers had some authority over most other workers, and weavers had some authority over smash-hands, but the lines of authority were confused and undefined. For example, the oiler could be directed by a jobber, but the relative authority of the two jobbers was not established. In the same way, the smash-hands could be given orders by a weaver, but the order in which the eight weavers could demand their services was not defined.

Work Organization

Because the production process of a loom shed, in contrast to that of a single loom, is continuous rather than cyclic, all activities in the shed were directed to maintaining the *steady state* of multiple loom weaving. Production in the shed, therefore, depended on the simultaneous execution of all activities. The activities were carried out by workers who performed tasks and took occupational roles. The tasks performed by the workers related their occupational roles to the activities of the shed. Because the activities of the shed had been broken down into their component tasks and the number of workers required to perform the tasks had been determined by work studies of the separate components, workers in different occupational roles worked on different numbers of looms.

There were eight loom groups of 24 to 32 looms manned by one weaver to each group; five loom groups of 40 to 60 looms manned by one battery filler to each; three loom

groups of 60 to 80 manned by one smash-hand to each; two loom groups of 112 manned by one jobber, one assistant jobber, one gater and one bobbin carrier to each; and the total loom group of 224 manned by one feeler-motion fitter, one cloth carrier, one oiler, one sweeper and one humidification fitter. This method of determining the number of workers required to carry out a total production process is the normal production engineering corollary of job breakdown and work study. Katz and Kahn (1951) have included it as a major factor in their concept of the Machine Theory of Organization.

Altogether, therefore, there were 12 tasks performed by 29 workers who, between them, took 12 occupational roles. Moreover, the looms in the shed were divided into five different kinds of loom groups which varied as to the number of looms, the number of tasks performed and the number of workers engaged in each group. Thus, the 12 tasks performed by 29 workers were performed in a total of 19 overlapping loom groups of five kinds.

Management Hierarchy of the Loom Shed

One consequence of the different kinds of loom groups and of the allocation of one component task to one occupational role was that the workers could not conveniently be grouped for supervision. Thus, in spite of the directive responsibility of the jobbers for all other workers and of the weavers for some, the work supervisor was directly responsible for 26 different individuals.

The overall picture of loom shed organization was a confused pattern of relationships among an aggregate of individuals for whom no stable internal group structure could be discerned. This picture may be both compared and contrasted with that found by Trist

and Bamforth (1951) in the longwall system of coal-mining. The effect there of job breakdown and task allocation led, especially on the filling shift, to a similar aggregate of individuals with no discernible stable internal group structure; but the sequential nature of the process led to splitting and isolation and the segregation of those engaged on component tasks of the total process both between and within shifts. In the experimental automatic loom shed the continuous nature of the process and the simultaneous performance of all component tasks led to confusion.

Change of Sort

A change of sort--kind of cloth woven--may change the work load of some of the workers. Thus a change of sort involving a change to a higher reed (greater number of threads per inch in the warp) may require an increase in the number of weavers because the greater number of threads may cause more frequent breaks, but a change involving a yarn of finer count may require a decrease in the number of battery fillers, gaters and bobbin carriers because more yarn could be wound on bobbins and beams. Without necessarily requiring an alteration in the total number of workers, a change of sort involved, therefore, a change either in individual work loads or in the kinds of workers employed. Each change altered the relationships between interdependent tasks and restructured some of the loom groups. Any change of sort was, therefore, likely to add to the confusion of task and worker relationships.

Government of the Shed

The work supervisor had so much to do in the handling of work allocations and of

worker relationships that the top supervisor had to assist him by dealing directly with jobbers and other workers. Indeed, had not the top supervisor so helped the work supervisor, it is difficult to see how he could usefully have filled his time. In the same way, the jobbers' technological tasks were so many and their supervising responsibility so undefined that the work supervisor had to assist them by giving direct orders to their nominal subordinates.

This breakdown of the hierarchical structure placed a high premium on the quality of the relationships between the supervisors and between the work supervisor and the workers. That the breakdown had led to no overt relationship difficulties was undoubtedly due in part to the high quality of the relationships, but it was also due to the considerable attention which had been given to the experimental shed by the chairman, mill manager and works manager ever since its opening. The lack of internal structure had been counterbalanced by a strong management structure external to the workers. In practice, the *governing system* of the shed--the system, external to the production system, which services, coordinates and controls the production system (Rice and Trist, 1952)--included members of higher management in addition to those shown on the organization chart.

In spite of this strong governing system, however, the current figures for efficiency were lower and the percentage of damaged cloth higher than budgeted targets. Faced with this shortfall in expected productivity there were, apart from technological improvements, two possibilities: to further strengthen the external structure of the governing system by increasing the number of supervisors and tightening inspection or, by reorganization, to create and stabilize an internal structure of the working group. The danger of the former was that the workers would not only continue to experience the discomfort of the internally unstructured

confusion but would feel further coerced and policed and, in consequence, might increase their resistance to greater effort and productivity. In addition, the presence of higher management in the governing system of the shed could only be temporary, and their withdrawal would leave gaps which would require more supervisors as replacements, thus enhancing any feelings the workers had of being regarded as untrustworthy.

The Socio-Technical System of the Loom Shed

Interdependence of Task and Independence of Workers

All tasks in the shed were interdependent, but many of the individual workers performing them were virtually independent in the sense that they were linked only through the work supervisor, while those who had interdependent relationships had varying degrees of interdependence in overlapping loom groups. Thus each weaver, depending on the sort on his looms, had on average the services of one quarter of the time of a dependent pair consisting of jobber and assistant jobber; five-eighths of that of a battery filler; three-eighths of that of a smash-hand; and so on. Any change of sort altered the proportions of the services he could command. Battery fillers each served, on average, one and three-eighths weavers; each smash-hand two and two-thirds weavers. With some sorts, the time of a particular battery filler might be completely consumed by serving the looms of two weavers and there was then opportunity for the two weavers and their battery filler to build interdependent relationships consistent with the interdependence of their tasks, but this was not a common pattern.

Generally, it may be said that the area of the shed and the number of workers were both too large and task relationships too confused for there to be much opportunity to build stable, cohesive relationships between the members of the total working group, and the confused loom groups precluded the formation of small, internally structured and internally led work groups consistent with task relatedness.

Job Breakdown, Multiple Grades and Worker Mobility

Job breakdown and consequent specialization had reduced the quality and range of skills required for performance of tasks in the loom shed. In contrast to conventional weaving, a weaver no longer had to service his looms, tune them, refill shuttles or stop the loom to prevent damage. Indeed, the loom itself had become the weaver and all the workers in the loom shed now serviced this mechanical weaver. In spite of the persistence of the title of weaver for one of the occupational roles, the weaver's task may be more accurately described as *loom-end-knotting*. (The similarity of this task to that of a *piecer* in ring spinning will be recognized by all who are familiar with the textile industry.)

In general, specialization of task had restricted the possibilities of task or role rotation. Because of low labor turnover, only the prospect of completion of the shed and the installation of more looms, an isolated event, held out any real hope of promotion or transfer. Even such an event only offered the opportunity of transfer from one specialized task to another.

Mobility was further restricted by the many different status grades which were allied to rate of pay. The rate of the jobber was 2.3 times that of the least skilled workers, and for the roles between these extremes there were seven other rates. Hence almost any exchange of

tasks would have involved a change of pay--a change only easy to accomplish in one direction. In short, the workers were chained to their roles and tasks.

Small Work Group Organization

Six assumptions were made about work-group organization, that:

> when individual tasks are interdependent, the relationships between those performing the tasks will have important effects on productivity.
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> groups of workers engaged in the same loom group are more likely to form internally structured stable and cohesive group relationships than those in overlapping groups.
>
> interchangability of tasks (role rotation) gives greater freedom of movement to workers.
>
> the coincidence of obvious physical and loom group boundaries enables a working group to realize itself and identify itself with its "territory."
>
> the fewer differences there are in work group status (and pay) consistent with offering opportunities for promotion, the more likely is the internal structure of a group to stabilize itself and the more likely are its members to accept internal

leadership.

> if group stability is to be maintained, when individual members of small work groups become disaffected to the extent that they can no longer fit into their work group, they need to be able to move to other small work groups engaged on similar tasks.

None of the conditions in these assumptions was satisfied by the existing socio-technical system. The tasks of the loom shed were therefore reexamined. The smash-hands were already accepted as weavers-in-training, and the weaver depended to a considerable extent on the efficiency with which the battery filler performed his task. The battery fillers, in their turn, had aspirations to become weavers. Bobbin carriers fetched all bobbins from the spinning department for the battery fillers. Assistant jobbers were already members of a pair, and gaters sometimes assisted jobbers to get looms running after a stop to replace an empty beam. The feeler-motion maintenance fitter was responsible for a specialist part of general loom maintenance. The oiler was under the nominal control of both jobbers and, although the sweeper and the cloth carrier each had his special task and were not considered interchangeable, they and the oiler were all graded as unskilled.

Short and Long Loom Stops as a Basis for Analysis

Cloth is woven only when the loom is running; all tasks in the shed are, therefore, directed to keeping the loom weaving. Loom stops are of two kinds: *short stops* caused by

simple yarn breaks (one-half to one minute) and *long stops* for gating (one to one-and-a-half hours), meal breaks (half an hour) and intervals between the second and first shifts (seven hours). During actual shift hours, workers could be divided into those whose tasks were directed to keeping the looms running through short stops and those whose tasks were to get the looms weaving again after a long stop. Thus, weavers, battery fillers, smash-hands and bobbin carriers were concerned with the weaving loom while gaters and cloth carriers were concerned when the loom was stopped for loading new beams at the back or for removing finished cloth from the front. At the same time, the jobber, assistant jobber, feeler-motion fitter and oiler had to use the opportunity of a long stop to obtain access to the loom for maintenance work. Even the sweeper had to use that time as his only opportunity to get under the loom to remove accumulated fluff. Only the humidification fitter was not concerned directly with looms and was, therefore, ignored in the subsequent analysis. The temporal analysis of the occupational roles and tasks in terms of short and long stops is shown in Table 1.

The reexamination of shed tasks and the temporal analysis of occupational roles and tasks suggested that two subgroupings were possible--a short stop sub-group and a long stop sub-group that would include those concerned with loading and unloading and with loom maintenance.

Table 1

Temporal Analysis of Occupational Roles and Tasks

	Tasks connected with			
	Short stops		Long stops	
Occupational roles	Weaving	Loading/Unloading	Loom maintenance	Department duties
Weavers	X			
Battery fillers	X			
Smash-hands	X			
Bobbin carriers	X			
Gaters		X		
Cloth carriers		X		
Jobbers			X	
Assistant Jobbers			X	
Feeler-motion fitters			X	
Oilers			X	
Sweepers			(X)	X
Humidification Fitters				X

Variation in Numbers Required with Change of Sort

Change of sort demanded substantial change in the number of battery fillers and gaters; some change in the number of cloth carriers and bobbin carriers; less change in the number of weavers; and virtually no change in the number of other workers. To examine the limits of the changes required, the theoretical number of looms which could be attended by weavers, battery fillers and gaters was calculated for each of the 16 sorts likely to be woven in any loom shed in the mill. These were then converted to show the number of workers who would theoretically be required to work 960 looms for all varieties of sort. (The figure 960 was chosen arbitrarily to give a large enough number to avoid too much approximation.) The result showed that although there were considerable variations in the number of weavers, battery fillers and gaters over the whole range, they could be grouped into three main sorts in which comparatively little variation occurred in the total number of weavers and battery fillers or in the number of gaters. These main sorts corresponded to the coarse, medium and fine counts.

Variation in the numbers of cloth carriers and bobbin carriers with change of sort was found to be too small to merit consideration. It appeared, therefore, that, provided weavers and battery fillers could be regarded as having partly interchangeable tasks, two kinds of workers would be required, whose numbers would vary with change of sort. The figures are summarized in Table 2.

Table 2

Varying Number of Weavers

Battery Fillers and Gaters Required for 960 Looms

Occupational roles	Numbers req'd for each main sort: Coarse	Medium	Fine
Weavers/Battery Fillers	60	42	38
Gaters	12	12	3
TOTAL	72	54	41

The numbers of other workers required for 960 looms based on the numbers in shed (Table 3.)

Table 3

Number of Other Workers Required for 960 Looms

Occupational roles	Number req'd for all sorts
Jobbers	8
Assistant jobbers	8
Feeler-motion maintenance	4
Oilers	4
Sweepers	4
Bobbin carriers	4
Cloth carriers	8
Smash-hands	12
TOTAL	52

Theoretical Work Group Organization

The results of these analyses were then combined with the results of the reexamination of related occupational roles. The combined result is shown in Table 4.

Inspection of the loom shed showed that the looms were installed in rows of 16 and that wide gangways separated off two blocks of 64. That is to say that a block of 64 looms was an easily recognizable territory separated from other looms by wide gangways and pillars. Further constructional work and the installation of more looms would turn two existing blocks of 24 into two more blocks of 64 looms.

It was therefore decided to start an experimental group on one block of 64 looms; to extend this, if successful, to the other block of 54 looms; and ultimately to use the block of 48 looms near the entrance of the shed as a training group. The figures for the theoretical number of workers required for 960 looms were, therefore, reduced to the number required for 64 looms and the results are given in Table 5.

Status Differences and Titles

An examination of the status grades showed that there appeared to be three natural grades, of which one would provide the group leader. These are shown in Table 6, together with the three proposed relative wage levels substituted for the nine current levels. For the group leader, the new grade involved a small rise in pay and for some previously designated "unskilled" the rise was larger. At the same time, whereas previously only jobbers and weavers were paid

piece rates,[2](2) it was proposed that all members of the experimental group should participate. It was hoped that any increased cost incurred by these changes would be offset by eliminating the need for extra supervision and inspection and by greater efficiency.

The wide difference between grades B and D led to the interpolation of a sub-grade C (rank 1.6) for those who had earned promotion from grade B.

It was recognized that the current titles given to occupational roles would not necessarily be appropriate to any form of reorganized internally led small work group since more of the tasks would be interchangeable. Various possible titles were suggested but the danger of expressing, consciously or unconsciously, hopes or expectations led to a decision to await discussion with the supervisors and workers before trying to define either the new grades or the new roles.

Other Aspects of the Analysis of the Socio-Technical System

The repeated examination of the occupational roles and tasks in the loom shed raised a number of other questions for which answers could not immediately be obtained or solutions, if obtainable, could not be immediately implemented. Some of these questions concerned the uniformity of the level of mechanization in the various shed operations; others would have involved analyses of other parts of the total textile manufacturing process. Time was not immediately available for the latter,and changing the level of mechanization in some

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[2](2) Piece rate was based on an average standard efficiency of 85 percent per month, higher or lower efficiencies resulting in proportional increase or decrease in the amount of pay, excluding "dearness" (cost of living) allowance which at that time was approximately 0.75 percent of the lowest wage. For an average monthly percentage efficiency of 87, the bonus equaled 2/85ths of the basic monthly rate (total pay less dearness allowance). For percentages over 92 the proportional increase was doubled, i.e., 93 was paid as 94, etc.

operations required the solution of engineering problems and the invention or development of further mechanical devices. Some alterations--for example, those related to the removal of fluff--were awaiting the arrival of equipment already ordered.

One outstanding question was that of the long loom stops caused by meal breaks and by intervals between shifts. Apart from insisting that, in general, the purpose of an automatic machine was to run without attention, it was decided not to suggest at once any alteration in the current practice during meal breaks. The question of intervals between shifts was complicated by trade union agreements and Indian Industrial Court awards and was left for future consideration.

Table 4

Theoretical Numbers of Workers Required for 960 Looms

		Numbers req'd for each main sort		
Sub-group	Occupational roles	Coarse	Medium	Fine
Short stop	Weavers/Battery fillers	60	42	38
	Smash-hands	12	12	12
	Bobbin carriers	4	4	4
	TOTAL	76	58	54
Long stop	Jobbers and Assistants/Gaters/ Feeler-motion fitters	32	32	32
	Cloth carriers/ Oilers/ Sweepers	16	16	16
	TOTAL	48	48	48
	GRAND TOTAL	**128**	**106**	**93**

Table 5

Theoretical Numbers of Workers Required for 64 Looms

		Numbers req'd for each main sort		
Sub-group	Occupational roles	Coarse	Medium	Fine
Short stop	Weavers/Battery fillers	4.0	2.8	2.5
	Smash-hands/ Bobbin carriers	1.1	1.1	1.1
	TOTAL	5.1	3.9	3.6
Long stop	Jobbers and Assistants/Gaters/ Feeler-motion fitters	2.1	2.1	2.1
	Cloth carriers/ Oilers/ Sweepers	1.1	1.1	1.1
	TOTAL	3.2	3.2	3.2
	GRAND TOTAL	**8.3**	**7.1**	**6.2**

Table 6

Status Grades for the Experimental Small Work Group

Grade	Status	Rank
A	Group Leader who would also be the working head of the 'Long stop' Sub-group	2.4
B	Fully experienced members of either the 'Short stop' sub-group or the 'Long stop' sub-group	2.0
D	Those engaged almost entirely on the 'unskilled' jobs of battery filling, sweeping, oiling or carrying, but whose status should nevertheless be higher than that of a new unskilled entrant once they had been accepted as integral members of a working group	1.2

Results of the Experiment

Spontaneous Acceptance of Reorganization

At a meeting of the chairman and the mill, works and personnel managers with the author, it was decided to discuss the analysis with the weaving master, the supervisors and the workers at once and, with their approval, to start an experimental group on the one block of 64 looms. The weaving master was called into the meeting, and as soon as he heard of the notion of *a group of workers for a group of looms*, he spontaneously accepted the proposed reorganization. His response provided for higher management a first validation of the "goodness of fit" of the proposed reorganization with the felt needs of those working in the experimental loom shed. The works manager started discussions with the supervisors on the same evening. It had been expected that it would probably take some time for the discussions to be held--first with the supervisors of each shift and then with the workers--and that the experimental group would then be chosen by the supervisors in consultation with the works manager and a suitable date for starting chosen. In the event, the supervisors and workers immediately took possession of the system and, by the next day, by a complex sociometric process which there was no time to investigate, the workers had themselves organized two experimental groups. By the following day, groups had been organized by the workers for the two blocks of 64 looms for both shifts, making four small work-groups (experimental groups ***a, b, c*** and ***d***). That the actual members of the groups so spontaneously chosen were not those who would have been picked by the works manager was considered (with some misgiving perhaps) less important than that the grouping

was spontaneous and that the number in each group had been spontaneously fixed at seven. There were only medium counts on the particular looms and each work group consisted of a long stop sub-group of one grade A, one grade B and one grade D; a short stop sub-group of two grade B and two grade D. The composition is shown in Table 7.

It was decided to allow the groups so chosen to work for an experimental period whose length would be determined by events.

Table 7

Composition of Each Experimental Group

	Number in each Sub-group		
Grade	Short stop	Long stop	TOTAL
A (leader)		1	1
B	2	1	3
D	2	1	3
TOTAL	4	3	7

Management of the Shed After Reorganization

The immediate effect on management after the shed had settled down to this reorganization was that the number of individuals reporting directly to the work supervisor was reduced. Although those workers not included in the experimental groups still continued as

before reorganization, those in the experimental groups were now responsible to their group leaders. In addition, workers requiring training, instead of being spread over the whole shed, could now be concentrated in one loom group of 48, where they could receive more direct attention from the supervisors. It was decided that, as soon as the building was completed and the full complement of 304 looms installed, the other two blocks of 64 looms would be organized in the same way as the experimental groups. This organization would leave the work supervisor with four group leaders reporting directly to him and would free the top supervisor to give special attention to the training loom group. Instead of the shed's needing more supervision, it appeared that there was every chance that the present supervisors would be underemployed. Figures 1 and 2 represent the situation before and after change.

The sophistication of higher management in permitting the shed to reorganize itself was followed by the beginning of their withdrawal from the governing system of the shed, not so much as part of a consciously determined plan but as the result of increased confidence in the ability of those in the shed to solve their own problems. In August, the chairman of the company reported that, "Whereas I always spent some time in the experimental shed every time I went to the mill (on average twice a week), I don't think I've been in it more than two or three times since it was reorganized, not because I've lost any interest in it, but because I know it is going well."

So far as the group leaders and workers are concerned, there has been no noticeable change in their attitude to the reorganization since their first spontaneous acceptance, and there have been requests from the workers not included in the experimental groups to be allowed to organize themselves in the same way. In discussion with the supervisors, the workers

Figure 1

Management hierarchy before change

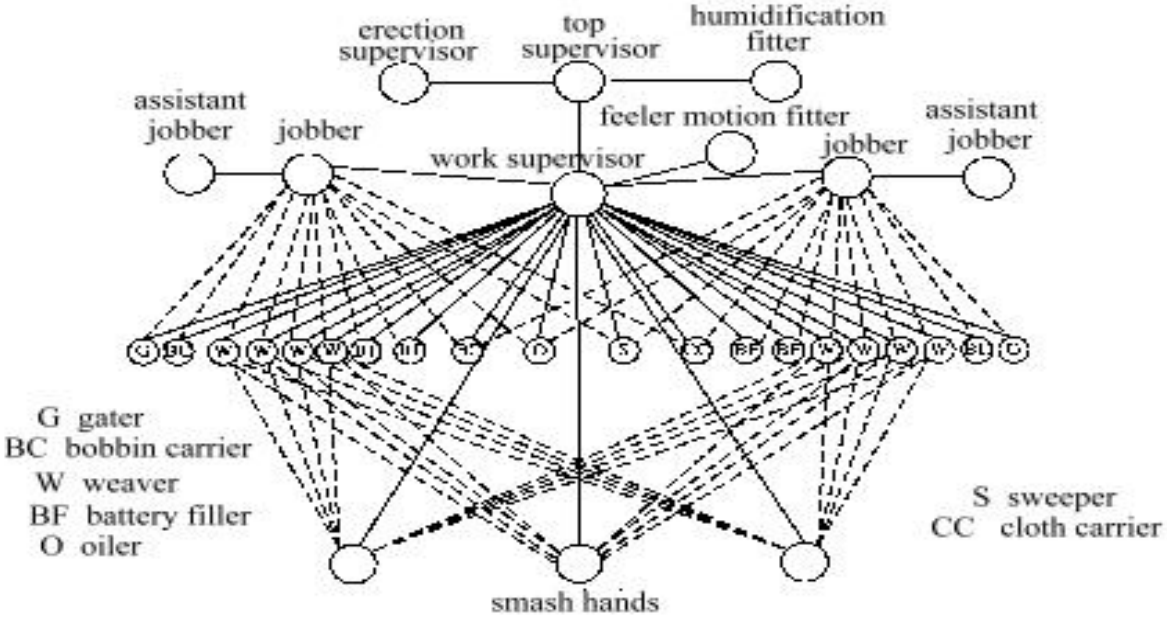
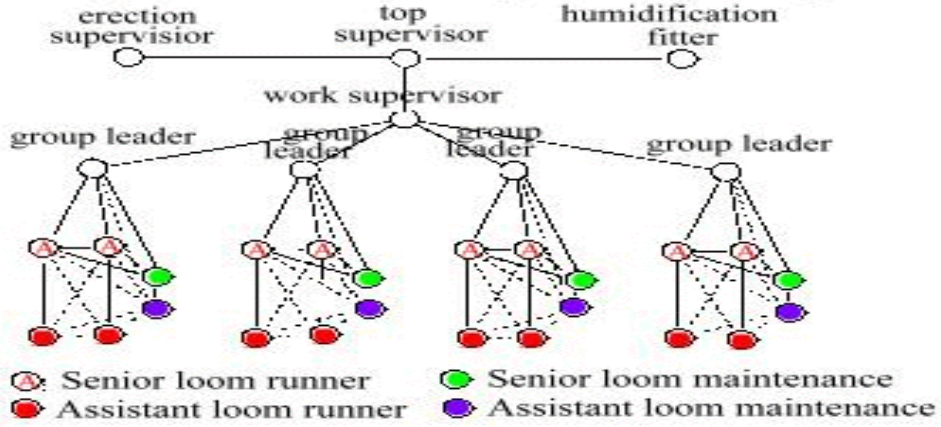


Figure 2

Management hierarchy after change



expressed a positive desire to avoid the old titles of their jobs but no enthusiasm for any other titles than the "A," "B" and "D" grade designations. In August (the latest information), experimental group tasks were still known by all those in the shed as "A," "B" and "D" jobs and those in occupational roles as "A," "B" and "D" workers.

In general it can be said that, as far as can be ascertained, the assumptions made about small work group organization have been proved correct.

Four Phases of the Experimental Period

A detailed consideration of the experimental period shows that it may be described in four phases.

First Phase--the 11 working days immediately after reorganization. During this phase there was an increase in the efficiency of the experimental groups but at the cost of an increase in the percentage damage and of neglect of loom maintenance. (This was apart from a problem on the second day when a breakdown in the humidification plant flooded a part of the shed, spoiled 25 beams in the experimental groups and halted the whole shed for just over an hour.) This problem was discussed by the works manager with the supervisors, group leaders and workers who expressed themselves as willing to cooperate in the attempt to reduce the damage and improve maintenance but as unable adequately to keep down damage and keep up maintenance while maintaining the rate of working

with short loom stops at l.5 to 2.0 per hour.

Second Phase--three working days during which the top supervisor took over the group leadership of one of the groups to investigate the possibility of maintaining efficiency while avoiding increased damage and decreased maintenance. As a result of this investigation, during which efficiency fell considerably in all four groups, extra help at the rate of half an extra grade D worker was given to each group (based on theoretical needs with loom stops per hour of 1.75.)

Third Phase--eight working days of resettlement following the damage and maintenance investigation. In this phase efficiency climbed, damage remained less than it had been before the experiment started and loom maintenance was restored to its former level (Figures 3 and 4). Discussions took place among the works manager, supervisors, group leaders and workers about the running of looms during meal intervals.

Fourth Phase--the remaining 37 working days of the experimental period. As a result of discussions during the third phase, looms were not stopped by the workers at the beginning of the meal break but were allowed to run on until they stopped automatically when yarn broke. It was found possible to withdraw the extra help given in the third phase--notwithstanding the fact that the incidence of loom stops was still l.6 per hour. After 37 days a partial third shift was started on

one of the experimental blocks of 64 looms and on one of the groups of 48 looms. Results thereafter are not, therefore, strictly comparable with those of the experimental period.

Figure 3

Percentage efficiency Before and After Reorganization

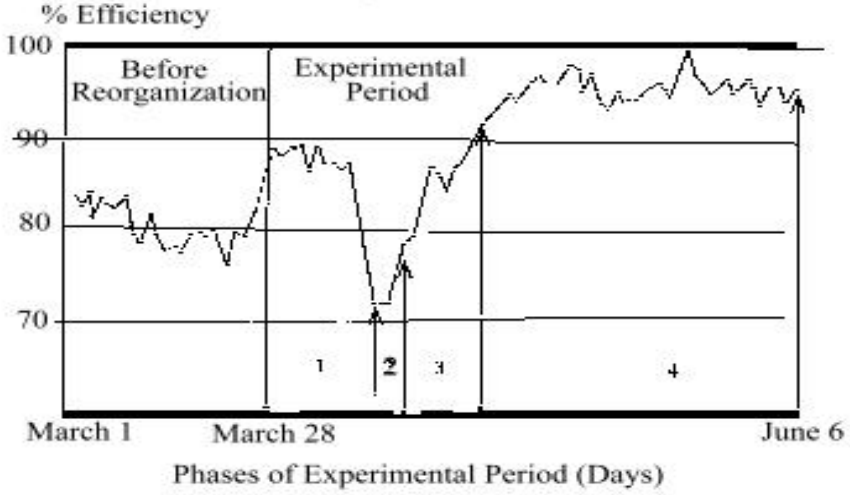
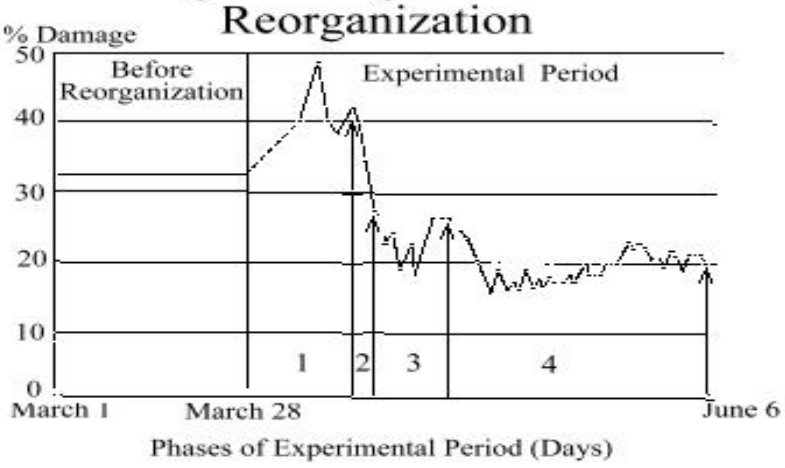


Figure 4

Percentage Damage Before and After Reorganization



Figures for Efficiency and Damage

The results of the comparison of the mean percentage efficiencies of the experimental groups with the mean percentage efficiency of the shed before reorganization are given in Table 8. (Figures are based on an eight-hour shift.)

Table 8

Mean Percentage Efficiencies of Four Experimental Groups Compared with Shed Efficiency before Reorganization

Phases of experimental period	*Experimental group*				
	a	*b*	*c*	*d*	*Combined*
1. March 30-April 10 11 working days	87.7	87.9	86.5	86.4	87.1
2. April 11-April 14 3 working days	67.7	69.6	73.2	79.8	72.6
3. April 15-April 23 8 working days	84.0	86.4	83.0	86.3	84.9
4. April 24-June 6 37 working days	95.9	96.2	94.0	94.1	95.0
Overall shed efficiency before reorganizationa March 1-March 28 23 working days	(79.8)	(79.8)	(79.8)	(79.8)	79.8

When the standard deviations of the distributions of percentage efficiencies were calculated, these confirmed a significant difference between the mean percentage efficiencies of each experimental group in the fourth phase and the shed efficiency before reorganization, and between the mean percentage efficiency of the combined groups in the fourth phase and the shed efficiency before reorganization. Except in the second phase (three days), they show no significant difference between the mean percentage efficiencies of the experimental groups or, in the fourth phase, between the standard deviations of the distributions of percentage efficiencies

of the experimental groups. The standard deviations of the distributions of the experimental groups are less for each group than that of the distribution for the whole shed before reorganization.

The results of the comparison of mean percentage damage of the experimental groups with the mean percentage damage of the shed before reorganization are given in Table 9.

Table 9

Mean Percentage Damage of Four Experimental Groups Compared with Shed Damage before Reorganization

Phases of experimental period	*Experimental group*		
	a & b	*c & d*	*Combined*
1. April 6-April 10 5 working days	37.8	45.5	41.6
2. April 11 -April 14 3 working days	31.2	36.2	33.7
3. April 15-April 23 8 working days	18.8	25.7	22.3
4. April 24-June 6 37 working days	17.8	21.9	19.9
Overall shed damage before reorganization March 1-March 28 23 working days	(31.8)	(31.8)	31.8

No daily damage figures were available for the period before reorganization or for the experimental groups for the first six days of the experimental period. Because there was no night shift in the inspection department, the damage of the experimental groups *a* and *b* and of *c* and *d* had to be combined.

The results show a significant difference between the mean percentage damage of each of the pairs of experimental groups and that of the shed before reorganization. They also show significant differences between the means of the experimental groups in all phases. The

differences between the means of experimental groups can be accounted for by difficulties with humidification during construction, which affected the 64 looms near the new building more than the others. The boundary of the affected area was, however, difficult to define and other factors (at present unknown) may have affected performance.

It may also be noted that in the period before reorganization the proportion of looms to workers (excluding the humidification fitter) was 8:1; that if eventually the number of workers in the shed had been found adequate to man 240 looms, the proportion would then be 8.6:1; and that in the experimental groups the proportion was 8.5:1 during the period when extra help was given and 9.1:1 after it was withdrawn.

Limitations of the Findings

The findings of the experiment are those of operational research. It was not possible, within the circumstances of the experiment, to relate the findings to the ecological background of economic, industrial or cultural conditions in India nor, because of language difficulties, was it possible to relate them to the attitudes and relationships of the supervisors and workers of the loom shed itself. The only evidence of the "goodness of fit" of the analysis was its spontaneous acceptance, rapid implementation and continuity. It may, however, be inferred that, by being permitted to implement their own reorganization, the workers were given a first experience of their own capacity to create an internal structure; and that management, in its turn, was able to accept the internal structuring of small work groups as a method of management and as an alternative to additional imposed external structure.

An examination of the efficiency and damage results in the rest of the shed--that

is, the looms other than those included in the experimental groups--strongly suggests the effects of forces of induction from the experimental groups. Theoretically, the rest of the shed continued with the previous form of organization during the experimental period. The formation of the experimental groups, however, had an inevitably disturbing effect on the whole shed and involved a reallocation of tasks and work loads among the rest of the workers. This disturbance, apart from any of the effects of being left out of the experiment, would have led to the expectation of induced negative forces in the experimental period. These expectations were confirmed by the results, but only in the first three phases of the experimental period. During the fourth phase, the mean percentage efficiency of the rest of the shed was 81.4 (shed efficiency before reorganization wass 79.8), and the mean percentage damage was 23.0 (shed damage before reorganization was 31.8). The full figures are given in Table 10.

Table 10

Efficiency and Damage Percentages for Rest of Loom Shed during Experimental Period

	Phases of experimental period	*Efficiency*	*Damage*
1.	**April 6-April 10** **5 working days**	71.0	42.7
2.	**April I I -April 14** **3 working days**	66.6	40.5
3.	**April 15-April 23** **8 working days**	68.9	26.6
4.	**April 25-June 6** **37 working days**	81.4	23.0
	Shed before reorganization March I-March 28 **23 working days**	79.8	31.8

The view that this improvement was a reflection of the success of the experimental groups was supported by a request from the workers in the rest of the shed to be allowed to reorganize themselves in the same way as had the experimental groups. Action was deferred until the end of the experimental period.

There is, as yet, no adequate information about the effects and repercussions in the rest of the mill. There have been no known adverse effects and some favorable interest has been shown. As far as can be ascertained, social, economic and technological conditions both outside and inside the mill and loom shed remained constant throughout the period for which results are reported in this paper. The only known change is that of climate, which grew steadily hotter from the beginning of March to the end of July.

On June 7 a partial third shift was started on one of the experimental groups of 64 looms and on one of the groups of 48 looms. The shift was started with new and comparatively inexperienced workers. It provided the opportunity for the upgrading of some of the members of the experimental groups and the reallocation of some tasks. The results since June 7 are not, therefore, comparable with those of the experimental period. The mean percentage efficiency of the whole shed for all shifts for the period June 8 to August 22 (the latest figures available) was, however, 90.3 (before reorganization, 79.8) and the mean percentage damage was 24.5 (before reorganization, 31.8). The works manager comments, "these results have coincided with the most difficult part of the year, working conditions are severe and absenteeism maximum."

Note:

In the concluding sentence of his original paper, Rice says, "The exploration has

led to arrangements for further collaboration. It is hoped, therefore, to follow up the experiment reported in this paper and to publish further reports as results become available." Such results were, in fact, published in his follow-up paper, "Productivity and Social Organization in an Indian Weaving Mill: II," Human Relations, 8:399-428, and further updated in his The Enterprise and Its Environment, Tavistock Publications, 1963.

References

Katz, D. and R.L. Kahn. 1951. "Human Organization and Worker Motivation." In Industrial Productivity: A Social and Economic Analysis, edited by L.R. Trip, Industrial Relations Research Association. Madison, Wis.: Solomon, Barkin.

Rice, A.K. and E.L. Trist. 1952. "Institutional and Sub- Institutional Determinants of Change in Labour Turnover." Human Relations, 5:347-71.

Roethlisberger, F.J. and W.J. Dickson. 1939. Management and the Worker. Cambridge, Mass.: Harvard University Press.

Trist, E.L. and K.W. Bamforth. 1951. "Some Social and Psychological Consequences of the Longwall Method of Coal- Getting." Human Relations, 4:3-38.