Eric Trist, Gurth Higgin, Hugh Murray and Alec Pollock

Alternative Work Organizations

An Exact Comparison (1)

A socio-psychological analysis of contrasting types of work organization on longwall faces in coal mines suggested that the composite form (2) was a better fit to the requirements of the mining system than the more widespread conventional form. To test this hypothesis, two comparative quantitative studies were made of ordinary coal production faces, geologically and technologically similar and not in any way experimental or otherwise atypical. The research design was based on a two-step comparison: the first, between two units with widely different sets of system characteristics, X (conventional) and Y (composite); the second, between two similar units, Y and Y(X), one of which had some of the X system characteristics.

(1) This paper is a revised version of Chapters 13 & 14 in E.L. Trist, G.W. Higgin, H. Murray & A.B. Pollock, *Organizational Choice: Capabilities of Groups at the Coal Face Under Changing Technologies: The Loss, Rediscovery and Transformation of a Work Tradition*. London: Tavistock Publications, 1963. Reissued 1987, New York: Garland.

(2) In composite working all members are multiskilled; they can exchange shifts and deploy succeeding tasks (task continuity); they share equally in a common paynote. The teams are self-regulating and pratice what we called responsible autonomy (Trist & Bamforth, 1951/Vol II). The terms "autonomous" and "semi-autonomous" are used interchangeably *in the literature*.

If the first comparison showed that Y was superior to X and the second that Y was superior to Y(X) then the hypothesis would be sustained.

Geological conditions in the seam were good though minor differences existed in the seam section and in the amount of stone, or dirt, *bands* within it. A "longwall" unit (or panel) consisted of two 80 yard faces on either side of a main *gate* (tunnel). Face conveyor belts fed on to a main conveyor that discharged into a hopper from which tubs were filled. Face supports were wooden props and steel straps with collapsible steel chocks which reinforced the support system. (This was the customary setup before faces became completely mechanized.)

The coal was won by undercutting the face with electrical machines (driven by *cuttermen*), clearing-out the undercut (by *scufflers*) to allow the coal to be drilled and broken from the face with explosives. On the next shift *fillers* shoveled the coal on to the face conveyor and set roof supports as the face was cleared, and *hewers* removed coal at the head of the main gate with pneumatic picks. The fillers are followed on the next shift by the *pullers* who advance the face conveyors and the steel chocks. At the same time the *stonemen* enlarge and advance the three gateways between and at the end faces of the panel.

The primary task was the daily completion of a scheduled three-shift production cycle. Arrangements for winding filled tubs of coal up the pit shaft fixed the relationships of tasks to shifts, with coal being filled-off at specified times, alternating between *fore-* (first) and *back-* (second) shifts, with no winding taking place on the *night* (third) shift.

The division of the primary task into the familiar sequence of cutting, scuffling, filling, hewing, drilling, pulling and stonework meant that there was technical interdependence between the different main tasks. How any one task group carried out its activities affected, directly or indirectly, what had to be done by others, as was the case also with the way places were kept and equipment handled or repaired. A good deal of coordination was required if the continuity necessary for the smooth running of the cycle was to be achieved.

A Comparison of Organizational Extremes

Characteristics of Two Panels

The first comparison was between a longwall organized on conventional lines and one organized on composite principles, faces representing the most extreme forms of work group organization encountered in the research. Comparison was made at a macroscopic level since there was reason to believe that differences of a major order would be disclosed.

Both panels were in the same seam, at neighboring pits. Geological conditions were alike, the same cutting technology was used and the haulage was similar. The set of task roles were identical on the two panels. There were, however, slight differences in manning. The total cycle group on the conventional panel comprised 38 face workers, that on the composite 41, the difference reflecting minor geological differences, pit custom and also the somewhat increased task size on the composite panel.

The work force on the conventionally organized panel was divided into 14 separate groups, each on a different paynote. These groups were defined by their responsibility for one main task, which, drilling apart, was on only one face or in one gate. Beyond this territory and this activity they had neither responsibility nor rewards.

On the composite panel, the workers had formed themselves into one whole group on one equally shared paynote; all members were jointly responsible for all activities. Although manning the same set of roles, they had a system of rotation whereby they changed main tasks, shifts and activity groups in a way that they had prescribed for themselves.

The effects on face worker behavior of these two different forms of organization will now be examined in terms of approach to work, non-cycle activity, inter-group relations, face experience and absence. An assessment will then be made of their effects on cycle progress, regularity of production and level of productivity. Finally, their consequences for management will be discussed, taking into account the roles of deputy, overman and undermanager--those concerned with face and seam management.

Differences in Face worker Behavior

As regards *approaches to work*, activities such as keeping the face in alignment and equipment in good running order, necessary to maintain the conditions for cycle completion, were of little concern to conventional work groups responsible only for one main task. Having no direct financial or group interest in the running of the cycle, they tended to be careless in these matters and not to mind how their way of doing their own main tasks might affect succeeding groups. Cuttermen, concentrating on yards cut, which is their basis of payment, did not bother if they cropped some of the coal and left it for the filler to dig out. Fillers, concentrating on tons filled, were not greatly worried by the consequences for the pullers of how they put in their supports. Pullers, in their turn, were not too careful about stacking withdrawn supports behind the belt and would leave them lying in the cutting track. All groups proceeded as though the cycle of operations were limited to their own task.

On the composite longwall, where there was only one team, all of whom shared a single primary task and a single paynote, groups anticipated the effects their activities might have on later shifts and anything likely to cause extra work was avoided. The standard of workmanship, therefore, was higher. The face was squared off and completely cleared, with no band or coal left lying; timber was in a straight line and gates and equipment were tidy. Quite different was the appearance of the conventional face, with spillage along the conveyor, timber badly set and gates and equipment in a rather neglected state.

These different approaches to work give rise to differences in the proportion of time spent on activities necessary for the progress of the cycle. Ideally, all work done by a face team is on main tasks and certain sub-tasks essential to their performance. To be contrasted is nonproductive ancillary work arising from disorganization or stoppages. Such *non-cycle activity* can never be entirely eliminated, but time spent waiting-on, doing overtime or going on to other work is an index of the extent to which the cycle is disturbed. Table 1 sets out the proportion of face time spent on ancillary tasks by the various groups on the conventional longwall. One-third of all their activities was of such a kind, though the proportion varied considerably between different groups, as did the reasons for its occurrence. For the driller, cuttermen and scufflers, time became available for work away from the face because their main tasks did not occupy a whole shift. Non-cycle activity for the fillers arose from interruptions caused by conveyor belt breakages and tub shortages. For the pullers it was increased beyond that of any other group by the call made on them to overcome cycle lag by filling off coal left on the face; an average of 11 percent was left on by the fillers and clearing this before beginning their own tasks accounted for

43 percent of the pullers' additional work. Only the hewers and stonemen, whose tasks were on the whole independent of those of other groups, had relatively small amounts of non-cycle activity.

TABLE 1

Non-Cycle Activity on Conventional Longwall

Task Group	Percentage of Face Time
Pullers	62 (a)
Cuttermen	45
Scufflers	45
Driller	45
Fillers	37
Hewers	16
Stonemen	8
Whole team	32

(a) Includes 43 Percent arising from coal fillings

For no task group, however, was more than 11 percent of the time spent on ancillary work due to unavoidable causes. Over all the groups this proportion was 7 percent. The remaining 25 percent was additional work made for one group by another. Although such extra work was seen as an imposition, there was no objection to its inheritance, because it was paid for, so that no one was discouraged from carrying out his main task in a way that created work for others. This pattern is referred to as the institution of *made work* and is a latent effect of the division of the cycle aggregate into single task groups.

The common, equally shared paynote of the composite longwall was based on an inclusive fixed minimum, which covered sub-tasks as well as main tasks and any ancillary work created. In addition, there was a large piece-rate component, 42 percent of possible earnings being dependent on output. The men had an incentive, therefore, to complete the cycle without making unnecessary work. Main and sub-tasks accounted for virtually all time spent at the face, non-cycle activity being only half of 0.5 percent.

Inter-group relations on the conventional longwall were at one and the same time competitive and collusive. Men had two sorts of relationship according to whether other face workers were inside or outside their marrow group. The marrow relationship, confined to members of their own main task group, was a close, friendly relationship in which work and earnings were shared and members trusted and supported each other. But they had far fewer marrow than non-marrow relationships. These latter, which comprised their contacts with those in all other task groups, were competitive, suspicious and unsupportive, with a psychological flavor of tension rather than ease, and offered opportunities for collusion rather than cooperation. The basis of the competition, which was covert, was ultimately financial as each task group aimed to maximize its own earnings, while management aimed to hold total face costs within reasonable limits. There were, therefore, 14 different pressure points on the same budget. But separate advantage could not be too openly sought without endangering "worker solidarity," the traditional weapon against management. Collusion over made work provided a convenient way out of this dilemma, especially as it was largely unwitting. Men on the composite longwall had a common goal and only marrow relationships with all their fellow face workers. Problems of this kind could not arise.

Table 2 summarizes the main factors affecting day-to-day *experience of face work.* Men on the conventional longwall did their one main task on only the two shifts to which it was assigned and always with the same group of marrows. On the composite longwall, because of the rotation system, the scope of day-to-day experience was much more varied. Men rotated among several main tasks, shared all three shifts and moved from one activity group to another.

Face work places many stresses on the worker, particularly when things are not going well. One way of reducing these stresses is by making it possible for the worker to have a change of task, shift or workplace. When difficulties arise, one or two groups usually bear the brunt: if the roof is broken, the pullers and perhaps the fillers; if fragmentation in the gates is bad,

TABLE 2

Variety of Work Experience (averages for whole team)

Aspects of Work Experience	Conventional Longwall	Composite Longwall
Main tasks worked at	1.0	3.6
Different shifts worked on	2.0	2.9
Activity groups worked with	1.0	5.5

the stonemen; if there is a small fault in the floor, the cutters. Seldom do all groups carry the . burden of bad conditions equally. When difficulties occurred on the conventional longwall, the group with the extra load had no relief, but on the composite longwall the stress could be shared.

One effect of the differences in the scope of work experience and the possibility of sharing out the more stressful tasks can be seen in the *absence behavior* of the two teams. Men on the composite longwall had in their task/shift rotation system a means of relief if some of the face work became unduly heavy, whereas on the conventional longwall those who suffered from bad conditions had to put up with them. Their working life, therefore, was more stress-inducing and the needs and temptations to withdraw--to be absent--were greater. This expectation of a higher level of absence is supported by the figures for comparative absence set out in Table 3, the

TABLE 3

Absence Rates (Percent of possible shifts)

Reason for absence	Conventional Longwall	Composite Longwall
No reason given	4.3	0.4
Sickness and other	8.9	4.6
Accident	6.8	3.2
Total	20.0	8.2

rate for all reasons being higher for the conventional longwall and that for voluntary absence over 10 times as great.

Effects on Production

We now turn to the effect of face group organization on maintaining production. *Cycle progress* on the conventional longwall tended to be erratic since a good deal of time was lost on nonproductive ancillary work caused by internal and external interference. During this time the cycle stood still. The best that could be hoped for was that main tasks would be up to schedule. For the cycle to be in advance was impossible because, even if a group should finish its own task early, it could not go on to the next as this was the preserve of another group. Indeed, the figures given in Table 4 show that lag was usual on the conventional panel. There was a tendency for the fillers especially not to be able to finish so that management had to take counteractive measures--pay the pullers to complete the filling and send reinforcements to the face to complete the pulling. So usual was cycle lag on the conventional longwall that it required an average reinforcement of 6 percent per week. On the composite longwall the cycle usually ran schedule. It could, and often did, get ahead of itself. This was because of the task continuity which was practiced, each shift group going on to the next tasks of the cycle as soon as they finished their own work. When lag did occur, the face team increased its pace of work in order to catch up, or at least to gain enough control so that the next cycle could proceed. They would, for example, under severe pressure, concentrate on finishing the most crucial tasks, leaving other work to be completed later. In this way the composite longwall maintained itself without reinforcement. Counteraction was taken by the group itself, mainly through the practice of group continuity. This was something the formally segregated single task groups of the conventional face could not do. Only management was in a position to take counteraction.

As for *regularity of production* on the two faces during the period of observation, the conventional longwall, with conditions quite normal, ran for only 12 weeks before losing a cut and during these 12 weeks usually needed reinforcement to complete the cycle. The composite longwall, on the other hand, ran for 65 weeks without losing a cut and at no time needed reinforcement.

As regards *level of productivity*, the conventional longwall, in terms of output per manshift (oms) at the face, yielded 3.5 tons and the composite 5.3 tons. The conventional was perceived as at the norm for the conditions and the composite as above it.

TABLE 4

State of Cycle Progress at End of Filling Shift(percentage of cycles)

State of Cycle Progress	Conventional Longwall	Composite Longwall
In Advance	0.0	22
Normal	31	73
Lagging	69	5
All Cycles	100	100

The seam sections, however, were different: the conventional face averaged 21" of coal and 1 1/2" of band, the composite 26" of coal and 6" of band, so that the latter had the advantage of more coal height, together with the disadvantage of more band, while the conventional had the reverse conditions. The seam haulages, though similar in type, were not equally effective and the interference caused on the conventional face was greater. Comparison of the face oms was not, therefore, possible without adjustment of the figures,y and each face was assessed against its own estimated potential. At 100 percent efficiency, 5.6 tons would have been expected from the composite panel and 4.5 tons from the conventional.

On this basis, and at first without any allowance being made for the greater amount of interference arising from its less efficient haulage, the conventional longwall was working at 67 percent of its potential (Table 5). In some measure this lesser efficiency of the haulage was due to poor maintenance resulting from back-bye labor being constantly drawn off to operating faces in order to cope with lagging cycles. It may therefore be regarded as a system defect. To some extent it was due also to the seam having been developed beyond the capacity of

TABLE 5

Productivity as Percentage of Estimated Face Potential

	Conventional Longwall	Composite Longwall
Without allowance for haulage system efficiency	67	95
With allowance	78	95

the haulage originally installed. A higher face productivity, however, would have increased the chances of something having been done about this when the working area was extended so that, once again, the effects of dysfunction cannot be entirely excluded.

If, however, in order to make the comparison more rigorous, full allowance is made for the higher level of external interference, the conventional face was working at 78 percent of its potential. The composite, by contrast, was working at 95 percent.

Effects on Management

Such different levels of effectiveness had very different consequences for face and seam management. On the conventional panel the entire burden of ensuring coordination of tasks and continuity of operations fell on officials. This entailed a great deal of effort, too much of which was expended on immediate measures necessary to counteract cycle dysfunction. With ancillary work at an overall level of 32 percent, the deputies (first-line supervisors) were heavily engaged in the detail of the ensuing complications, arguing with various task groups on precisely what needed doing and bargaining over amounts due and items eligible for payment. Apart from their statutory duties, such as patrolling their districts, testing for gas and ensuring application of support rules, the deputies' time was almost entirely absorbed in taking emergency action over technical breakdowns or tub shortages, events arising from system dysfunctioning, and in administering an itemized price list. Some idea of the demands of this latter activity can be gained from Table 6, which sets out the number of items involved in settling the pay of the different task groups on the conventional panel during an experimentally recorded quarter (13 weeks). Small opportunity was left to the deputies for attending to matters that, on a longer time

Table 6

Items in the Price List of the Conventional Panel during One Quarter

	Task groups affected								
Type of item	*Pullers*	*Fillers*	*Cuttermen*	*Scufflers*	*Maingate stonemen*	*Driller*	*Hewers*	*Tailgate stonemen*	*All groups*
A	15	11	4	3	5	4	6	4	52
B	22	16	18	18	14	14	9	7	118
A + B	37	27	22	21	19	18	15	11	170

A* Items for which the rate (though not the amount in any instance) is fixed by agreements; B, Items for which neither the rate nor the amount is fixed by agreements (items covered by shift work)

span, would have reduced the level of interference.

The time and energy of the overmen (second-line officials responsible for the work of the shift) were similarly consumed in dealing with immediate problems. With six to eight faces operating in the seam, the overmen on the first and second shifts were obliged to give priority to getting as much coal out as possible from whichever faces were filling off, and most of these were usually to some degree lagging. They deployed men and tubs accordingly, improvising to secure maximum production for any given day. The overman coming in on the early nightshift had an even greater struggle, having first to eliminate whatever lag remained on all faces--with only limited winding time left--and then somehow to see that each face was advanced or cut so that the next day's cycles could proceed. What was intended as the principal maintenance and development shift became the principal troubleshooting shift, with men drawn off from repair and development work to reinforce lagging faces and those tasks falling behind which alone could maintain the level of seam functioning. To break the vicious circle at the overman level, however, was possible to no more than a limited extent since the greater part of the dysfunctioning was being generated anew every day within the face districts themselves--25 percent out of 32 percent on the face selected for detailed study.

The undermanager, the first official with overall responsibility for the cycle, was already three steps in managerial rank away from the coal face, a distance too great to exercise immediate control. He was more worried about keeping down costs than about raising productivity, tacitly accepting the latter as impossible without a degree of change outside his scope to initiate. Such an attitude, expressing a solely defensive strategy, is the natural corollary of being in a situation where no positive improvement is seriously hoped for. In keeping with this attitude, he saw his problems as arising more from the power of task groups to bid up prices than from the inflation of face costs by system dysfunctioning.

Both he and the colliery manager had commended the seam as an example of a "very normal and well established" longwall operation--"a regular producer, pretty good conditions, a reasonable crowd of men though sharp about wages"--and this was also its reputation with higher management. The extent of cycle dysfunctioning was not perceived, the existing level of performance having come over the years to be accepted as the natural one. That the dysfunctioning might be due ultimately to the way the face team was organized was not believed when the present results were first discussed, though as time went on attitudes changed both at the colliery and in higher management. But initially an attempt was made to explain away as a special case what had been presented as typical. Several of the faces, it was said, were nearing the boundary so that only a limited investment in maintenance and new equipment had been justified; hopes were now placed in another group of faces soon to be opened out in a new area of the seam. When the research team visited these faces some months later, external interference was certainly reduced but coal was still being left on by the fillers, even if not so much or quite so often. The character of the disorganization, however, was unaltered. and over the course of time it would, in our opinion, have built up again toward its former level had not various technological changes ensued.

There was no greater contrast between the conventional and composite faces than in their management. As the composite organization was self-regulating, immediate cycle control was established by the group itself. The deputies needed neither to coerce, as it was in the interests of the men to get ahead, nor to bargain, as an allowance for an agreed range of sub- and ancillary tasks had been built into the Agreement. The comparable figure for the composite panel to the 170 items arising in the price list of the conventional panel was seven. Freed in this way, the deputies were able to give more time both to safety and to anticipating the needs of their districts. The center of gravity of their role changed from "propping up" a cycle always to some extent falling down on itself, to meeting the input and output needs of a going concern. To have the face cycle make demands on the deputies rather than the the reverse was disconcerting at first, and a number of deputies felt their jobs had vanished. All but the most rigid, however, were able to readjust by taking a more active part in regulating the interactions of the face and the seam systems and to perceive the management of this "boundary zone" as their real task.

The existence of a self-regulating primary work group exerts an upward pressure in a managing system which affects all roles. With the elimination of made work by the face teams and with the deputies more active in seam liaison, one of the three overmen became superfluous. A single official, working a split shift, coped with both fore- and back-shift, establishing unified control over the production shifts at two rather than three levels from the coal face. This emergence of unified production control over an unlagging cycle enabled the overmen to maximize the maintenance function of the night shift so that almost all external interference was eliminated. The standard of maintenance in the entire seam system connected with these faces was of an altogether different order from that encountered elsewhere in the research.

All this allowed the undermanager to spread his attention to other seams which were more in need of it. He became more of an assistant manager. The extent to which a steady state had been reached may be gauged from the comment of the manager: "Now, I don't know that I have these faces in my pit." At the opposite extreme is the degree of involvement of this same manager in the panel described in Volume I (Trist et al.), where the primary work group failed to become self-regulating. As the whole colliery was undergoing reorganization at this time, such involvement could be ill-afforded. The freedom needed higher up to manage change constructively is only won by establishing some freedom to manage at the bottom.

The emergence of a self-regulating primary work group undoes what Jaques (1951) has called the split at the bottom of the executive system, as there is no longer the same ultimate division into managers (of all ranks, including supervisors) and managed. Some of the managing has been taken over by the primary group--the part appropriate to its own task. Though this is what many in industry were allegedly seeking at this time and though a managerial philosophy was coming into existence which made this explicit (McGregor, 1960; Likert, 1961), such a development creates anxiety and produces resistance. In the present instance, the management/union negotiations went on for a year and might easily have broken down had not higher management lent support. The first difficulty is letting go of the traditional managerial controls over the primary group; the second is accepting the challenge of the consequent rise in the level of work now required within management. To surmount these difficulties, however, is to replace job alienation in the worker by task-oriented commitment; thence, by reducing the pressure of immediate troubleshooting, to increase the scope for creative problem-solving in management.

One qualification must be made to these conclusions. They have been drawn from comparison of only one conventional and one composite face. The two selected faces were as closely similar as field conditions would allow and where dissimilarities existed adjustments have been introduced. The aim has been to approximate in a fieldwork situation the design of a crucial experiment, the efficacy of the comparison depending on the identity of conditions rather than on the number of cases. Though complete identity cannot be claimed, the approximation obtained may be regarded as sufficient to establish the direction, if not the magnitude, of the result (cf. Lewin, 1935, chapter 1). There are, of course, many conventional faces operating more efficiently than that studied and other composite faces operating less well than the example given. Indeed, an overlap is to be expected, with the better conventional faces having production records superior to those of the less effective composite faces. One comparison does not enable the performance range of the two systems to be investigated or estimates made of their mean levels of functional effectiveness. Such a qualification does not, however, invalidate the general conclusion concerning system characteristics: that the technical progress of the primary task is disrupted, in the conventional case, by disturbances induced by a fragmented social system;

while, in the composite case, it is carried forward by the more continuous activity pattern arising from an integrated work group.

A Comparison of Partial and Fully Composite Working

Two Composite Organizations

The second comparison was between two composite longwalls, one of which was less composite than the other in the sense that its work organization had some features which were to be found on the conventional type of face. Since productivity differences were expected to be small, comparisons had to be carried out at a microscopic level. Placed on a scale of compositeness, the two longwalls just compared represent the extremes. A scale of compositeness would range from a strictly conventional organization with one-task/one-shift roles and no interchange between task groups to a fully composite organization with multi-task/multi-shift roles and completely free interchange between task groups. We shall now compare two composite longwalls, one of which--that used above--was closer to the composite end of the scale than the other.

Apart from the type of group organization that each developed for itself, these two panels were more alike than one would expect two longwalls to be, even in the same seam in the same pit. They were adjacent. They used exactly the same technology and worked to the same Agreement. Seam conditions were identical and the teams indistinguishable in qualifications and experience. They shared the same haulage and services. Both teams followed the composite work method as regards the practice of task continuity. The men were multiskilled workmen, all qualified for filling, drilling, pulling and stonework, and between one half and two thirds also for cutting. Both teams were self-selected and accepted complete responsibility for allocating themselves to the various jobs that management required them to fill. The method of payment was an all-in flat rate plus a piece-rate bonus, the common paynote being equally divided in each case among all team members.

This was the general form of the composite system originating in the seam. Nevertheless, over time the panels developed rather different ways of organizing themselves. The main differences (summarized in Table 7) were as follows:

Table 7

Differences between Panels in Face Group Organization

No. I Panel (less composite organization)	*No. 2 Panel (more composite organization)*
Face-wide: organized as two rather separate face teams.	Panel-wide: organized as two main alternating shift groups over the whole panel.
One-task jobs: men tend to work at only one main task.	Multi-task jobs: men rotate tasks systematically.
Each work place and task tied to a particular man.	Work places and tasks not tied to individuals.
Not customary for men to move from one work group to another,	Men move freely from one work group to another.

The group on No. l Panel organized itself as two face teams, each taking responsibility for manning the three shifts on its particular face. This face-wide organization distinguishes it from the panel-wide organization on No. 2 Panel where no distinction between the two faces was made, the team dividing itself into two main shift groups, each with 20 men. Every fortnight the main shift groups alternated between the filling and pulling/stonework shifts and between them provided the men for the cutting shift, while the driller remained quasi-permanent.

No. 1 Panel organized itself so that men tended to stick to one main task. For example, they would work as fillers or pullers, but not as both. In some ways this pattern is similar to that found on conventional longwalls but, since No. 1 Panel worked in the composite manner, all men became involved, in addition, in other tasks. Nevertheless, No. 1 Panel developed one-task roles. On No. 2 Panel, because men alternated between filling and pulling/stonework every fortnight and went on to cutting on a longer time basis, men carried out a range of different main tasks. They developed multi-task roles.

On No. 1 Panel the team organized itself so that each specific job on the panel was the responsibility of a particular individual. The men tied themselves to work places and tasks. On No. 2 Panel, so long as all workplaces and tasks were manned by qualified team members, it was immaterial who they were. Jobs were not tied to individuals.

No. 2 Panel team members moved freely from one activity group to another, not only from day to day but from week to week. A man could, for example, when filling, change from one face to the other. On No. 1 Panel there was little movement of this kind; men definitely tended to stick to one work place. It was not their custom to move, though movement was permissible.

These four differences in face group organization were not so extreme as indicated in that some of the features occurring on one panel were found on the other, especially as time went on. The differences, nevertheless, had consequences in three main areas--production performance, adaptation to changing conditions and effectiveness of cycle regulation.

Production Performance

It was planned that the two panels should produce half of the total pit output with a fifth of the face manpower. From the outset, the panels achieved this target. A face oms of the order of 5.3 tons was maintained without reinforcement of the 41-man teams throughout the 20 months of their operation. Both panels went for over 15 months before losing a cycle. In all they lost only 12.5 cycles out of 730 scheduled--1.5 percent.

Changes in conditions, however, must always be taken into account in assessing a performance record and to permit this, the concept of a production phase was introduced to indicate a period of time during which conditions in the task environment remained relatively constant. Data taken from pit records were analyzed to show what happened in four consecutive phases of production--A, B, C and D--each of which lasted some five months and between which there were identifiable differences. Figure 1 summarizes the results. Differences were greatest between D and the other three phases. This was the period when cuts were lost and at the end of which geological conditions had so far deteriorated that the faces were stopped.

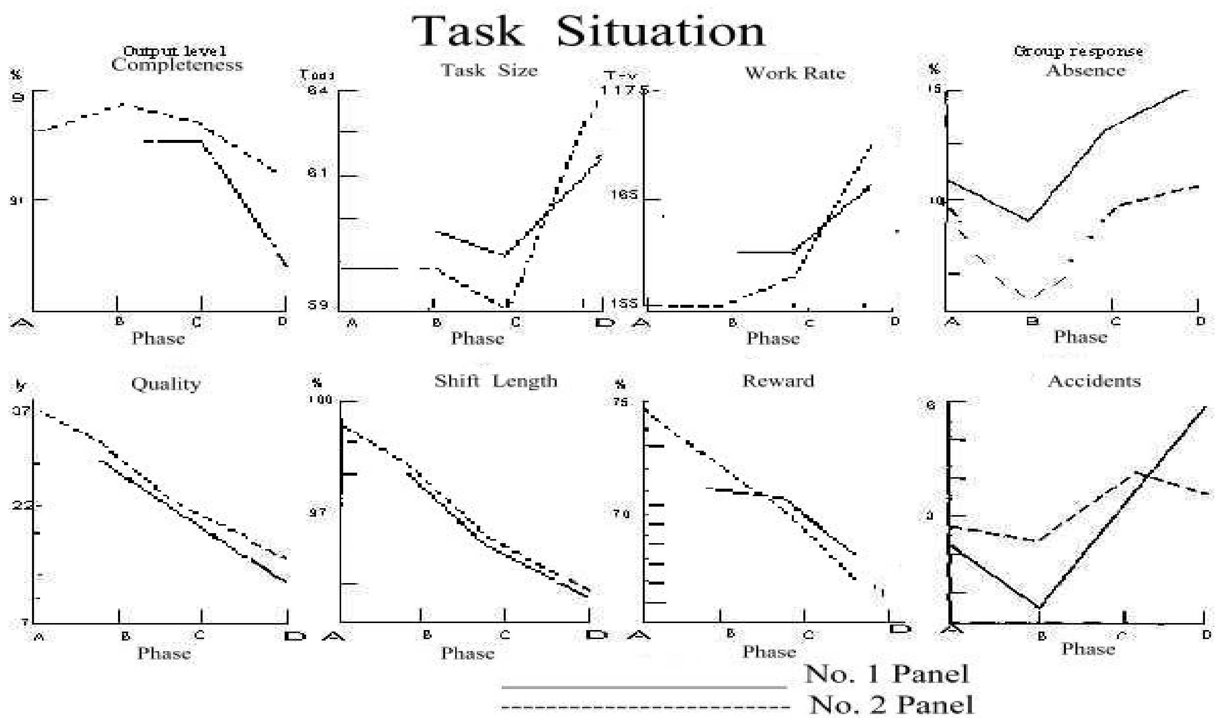

Figure 1 Performance record of two composite logwalls

The completeness index relates actual production per month to that estimated from coal height, face length and amount of advance. In phases A, B and C the completeness index was over 93 percent on No. 1 Panel and over 95 percent on No. 2 Panel, but in phase D it dropped to 87 percent on No. 1 and 90 percent on No. 2. The level of completeness on No. 2 Panel was always higher than on No. 1 Panel by 2 to 3 percent. In tonnage terms, this amounts to only 20 to 30 tons a week. It appears so regularly, however, that it cannot be regarded as due to chance. There is, therefore, a consistent difference between the panels in the extent to which they extracted all that coal be won by the given system of working. The seam was a particularly dirty one and from the outset it was recognized that to attempt a high degree of separation of band from could would endanger cycle completion. The index for quality of performance shows both a low initial level and a marked downward trend, more and more band being filled off with the coal. As the panels advanced, the coal height fell steadily while the amount of stone-band increased, eventually to a point where, as has been mentioned, economic working was no longer possible. During the first three phases a high level of completeness was maintained, though quality declined. Phase D saw not only a continued drop in quality but also a marked lowering in the level of completeness due to an increasing number of lost cuts. Throughout, however, No. 2 Panel did better than No. 1 Panel.

The declining height of the seam and the increasing proportion of band had two consequences. First, since band is almost twice as heavy as coal, the job became more onerous. Second, the falling coal height led management in phase D to increase the depth of undercut in order to maintain production. The gross effect was that a considerably heavier load of coal and band had to be handled by the team, as seen in the graph headed Task Size in Figure 1. Although in phases A, B and C the task size decreased slightly, in phase D there was a very steep increase. As the panels advanced, the effective length of the shift available for work at the face decreased noticeably, the decrease shown in the graph headed Shift Length being equivalent, by the end of phase D, to a reduction of two manshifts per cycle--in a team of 41 men approximately 5 percent. The operations of the cycle had therefore to be compressed into shorter periods and the graphs for Quality and Shift Length follow a similar downward trend, showing that, with less time to do the job, quality suffered. With the increase in task size, and the decrease in time available, the teams had to work at a faster rate, as shown in the graph headed Work Rate. While the required rate was much the same in the first three phases, in phase D it increased greatly and for the fillers this meant handling 17.5 tons per manshift. Relating this to the drop in completeness, one may conclude that beyond such a limit cycle completion becomes endangered.

On both panels the piecework bonus was determined by the cubic yards of coal extracted. As coal height became less, so did possible earnings, since at that time the piece-rate did not take changes in coal height into account. Another way of looking at this situation is to consider what proportion of the effort expended during the shift was devoted to fill off coal as distinct from band. If 10 tons of coal and band had to be handled and 8 tons of this was coal, then 80 percent of the effort would be rewarded; on the other hand, if there were 12 tons of coal and band of which only 8 tons was coal, then no more than 66 percent of a man's work would be paid for. The graph headed Reward shows that, as the panels advanced, possible earnings bore less and less relation to the effort required. The similarity between the graphs for Quality and Reward shows one effect of this.

Though No. 2 Panel had a rather rougher time than No. 1 Panel, both followed a similar course, completeness of production falling sharply in the last phase when cycles were lost. This coincided with an increase in task size, a reduction in shift length, a faster work rate and a growing disparity between effort and reward. All these changes operated as a stress on the team who had, essentially, to deal with a bigger load. This may be referred to as work load stress.

Adaptation to Changing Conditions

One useful indicator of response to the stress of increased work load is provided by the absence record of the panels. During the period of the study, the face worker absence rate for the pit as a whole averaged 12 percent, but the panels themselves were below this level --10 percent for No. 1 and 8 percent for No. 2. The differences are significant not only between both panels and the rest of the pit, but also between the two panels themselves. Again, the trend favors No. 2. To investigate this more fully, absences during phase D--when the work load increased--have been compared with those in phase C, in which the work load was much the same as during the preceding phases.

The changes between these two phases produced striking differences of response from the two panels as may be seen on the graphs headed Absence and Accidents. On No. 1 Panel the absence rate increased with rising stress, on No. 2 Panel it remained unchanged. Figure 2 presents a fuller picture of these changes under Stress and Withdrawal (which gives the incidence trend in absences from all sources). On No. 1 Panel the rising absence rate was due largely to an increase in absences lasting only one day (c.f. Hill and Trist, 1955/Vol. I). There was, particularly, an increase in the incidence of one-day sicknesses and also an increase in accidents leading to a day off. No significant change, however, occurred in voluntary "no reason" absences. On No. 2 Panel, the changes in one-day absences were so small that they could have come about by chance. While increased stress showed itself on No. 1 Panel as a definite increase in the number of single days off, the incidence in phase D being double that in C, No. 2 Panel showed no difference. It follows that the team must have had some alternative and more effective way of coping with work load stress.

Given the equivalence of the two groups, the differences cannot be explained by assuming that the men on one panel were more susceptible to infection or more accident prone than those on the other. Rather, an explanation must be sought in terms of the way in which the two teams organized their work. On No. 1 Panel, where increased stress and absence go hand-in-hand, the team organized itself so that each man was tied to one main job. It was not the custom to move from one work group to another as the graph in Figure 2 headed Relocation shows. Since the wages of the team were dependent on the successful completion of the cycle, each man felt personally responsible for maintaining the progress of the cycle on his own shift and for coping with whatever interference might arise in his own workplace. On No. 2 Panel, where greater stress did not lead to increased absence, the team organized itself so that over a period of time each man carried out a wider range of tasks; men were not tied to a particular job and moved freely from one work group to another. Consequently, excess load did not fall on particular men; rather, it was spread over the team as a whole. The Relocation graph shows a level of movement more than twice as high as on No. 1 Panel.

Movement across activity groups was, however, lower on No. 2 Panel during phase D than during phase C when it was over three times as high as on No. 1 Panel. When conditions became rougher the team saw to it that the most crucial roles were occupied only by the most experienced men. Substitutes were never sent on to cutting or pulling, or to where the roof was bad, and less experienced "regulars," or men who were not too fit, were kept in positions of less moment to the cycle. This was adaptive behavior, showing the realism and task-orientation characteristic of the group climate. Enough team members had the necessary experience to prevent any one from having to bear the brunt too long, but certain types of movement were not restricted to those who composed the informal "elite."

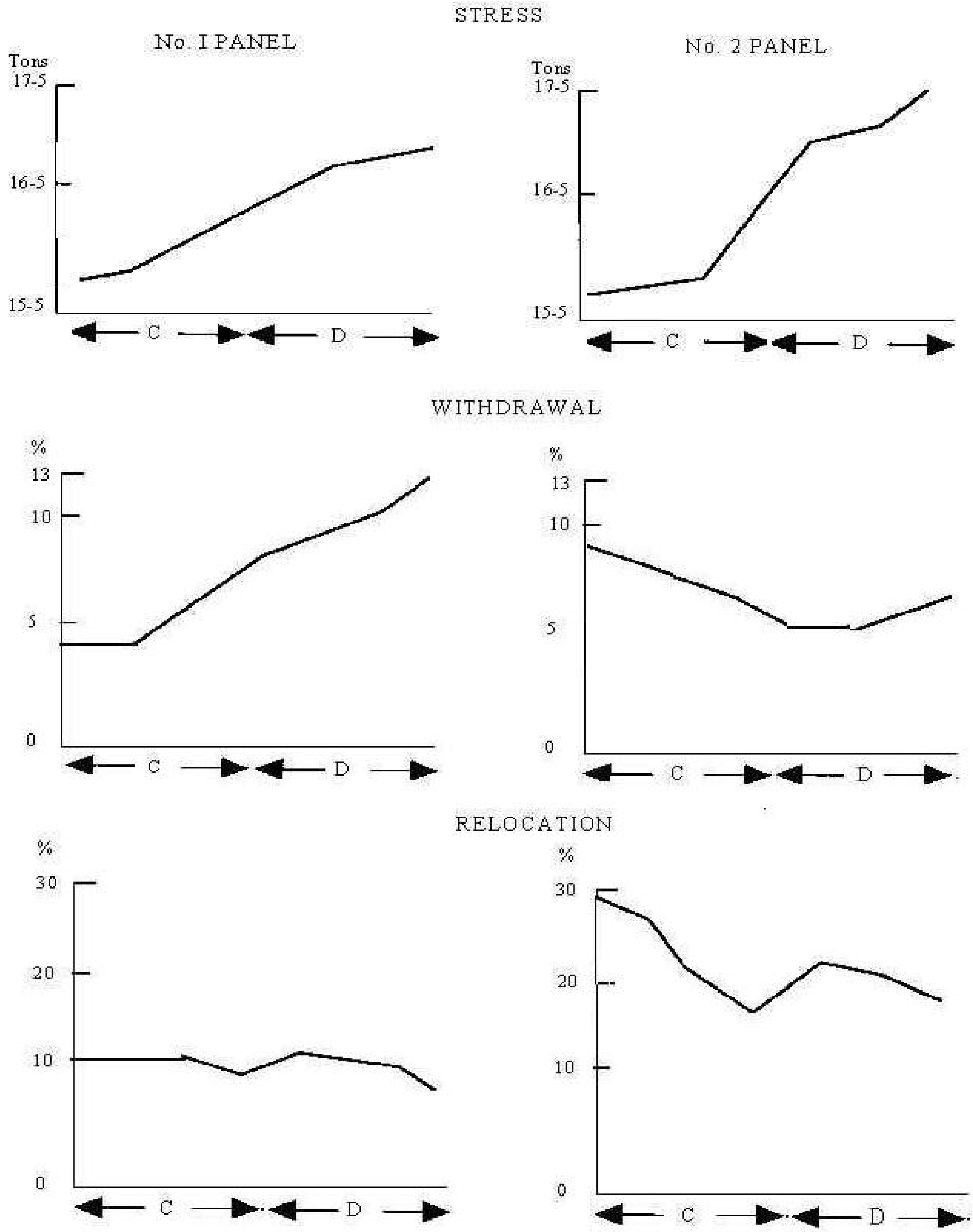

Figure 2 Stress, Withdrawal and Relocation

Cycle Regulation

In order to appreciate more fully the way in which the underlying differences in face group organization affected performance and adaptation to stress, it is necessary to examine how the two teams regulated cycle progress. Although composite teams spontaneously carry on with whatever job has next to be done, how far a shift can, or even should, proceed with the work of the cycle is governed by a very complex set of factors. Basically, it depends on what stage the cycle is at when the men come on shift. A quantitative study of the regulation of cycle progress during phase D, when the roughest conditions were experienced, was made by comparing, for each different beginning, the average state of the cycle at the end of the shift. For example, when the cycle is lagging because the cuttermen did not finish their work, the fillers manage to finish the cutting and also to complete their own work--they put a spurt on in order to eliminate the lag. When the cycle is normal, normal progress is made. When the cuttermen achieve a slight of medium advance and give the fillers a start, by the end of the shift the fillers have pushed the cycle a little further ahead. When, however, substantial advance is made by the cuttermen, the fillers aim simply to maintain it, there being no virtue in the team getting the cycle too far ahead, for the smooth running of the seam as a whole could be disrupted. The inference to be drawn for all shifts--cutting, filling, pulling and stonework--is that the teams were able to regulate their work to suit the varying conditions and to satisfy the requirements for optimum running of the seam system as a whole.

The panels differed considerably in their method of gaining control over cycle lag. On No. 1 Panel, lag of whatever degree--short of actual breakdown of the cycle--was eliminated during the shift that inherited it, whereas on No. 1 Panel two or three shifts would be allowed to elapse before the cycle was brought back into phase. The men on No. 1 Panel would not pass on any inherited lag to their marrows on the succeeding shift. Their attitude was that every shift should attempt to bring the cycle back into phase, regardless of whether control could be more economically achieved by passing on some of their work to the next shift. When the work load increased, each group, by attempting complete control over any lag it might inherit as well as aiming to finish its own job, raised still further the level of stress. In time, the greater strain which men experienced resulted in greater absence. Such were the consequences of a face group organization which tied men to particular jobs and limited interchange between work groups. On No. 2 Panel, by systematically rotating the various shifts, men came to know better what could be done under the conditions of each shift. They did not expect a particular shift to achieve complete control but accepted as quite reasonable that some of the consequences should be coped with by later shifts. With a span of three shifts as compared with one in which to eliminate lag, they therefore experienced less strain and no significant increase in absence occurred.

There was one other difference between the panels arising from the practice of having one face advanced by one cut ahead of the other (following) face. To ensure a smooth succession of cycles, operations on the advanced face needed to be slightly ahead of those on the following face, and close cooperation of the men working on the two faces was necessary for this optimum situation to be achieved. No. 2 Panel, which was organized on a panel-wide basis, always kept operations on its advanced face slightly ahead of those on the following face. When anyone was required for shift work in the gates, men were drawn from the following rather than the advanced face. The team also concentrated lost cuts on the following face--making the best of a bad job. No. 1 Panel, with its two rather separate face teams, operated quite differently.

They kept operations on both the advanced and following faces closely in step. When men were required for shift work away from the face, they were drawn equally from both faces. Cuts were lost with the same frequency on both. This overall method of cycle regulation was suboptimum for the particular technology and the double-unit layout. The difference between panel-wide and face-wide organization had very real consequences for the regulation and progress of the cycle.

This comparative study indicates that one form of face group organization was a better fit than the other to the requirements of the situation in terms of

> the productivity of the faces--though there was little to choose between them, such differences as there were consistently favored the group organized on a panel-wide basis.

> regulating cycle progress--though on both panels the practice of task continuity enabled the teams to get sufficiently ahead to cope with inevitable and unpredictable difficulties and interferences, the differences definitely favored the same panel.

> the social cost of maintaining a high production record--in sickness and accident absences, which arise from the way increased work load stress is coped with, there were considerable differences which again favored the same panel.

The face group organization that was panel-wide embodied systematic rotation of the various jobs among team members and did not tie a man to only one job, work group or face; it was the more effective in maintaining the smooth flow of the cycle and in coping with increased work load stress.

The differences in the operational records of these two composite longwalls are to be accounted for by the presence of certain "conventional" features in the face group organization of the less effective panel. The comparison of a conventional and a composite longwall showed that the superior production performance of composite organization stems from its more effective regulation of cycle progress. The second comparison is more stringent--that of two composite longwalls working under almost identical conditions though differing in their internal work organization. The results show unequivocally that the presence of conventional characteristics affected the way one of the panels regulated its work and caused a depression of its performance level, while increasing "casualties" in the face team. This two-step comparison leads to the general conclusion that, for workers carrying out a primary task comprising interdependent component activities interchangeable between group members, the composite form of organization has inherent characteristics more conducive to productive effectiveness, work satisfaction and social health than that based on separately treated single task groups.

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