

ORGANIZATIONAL CHOICE

Capabilities of Groups At The Coal Face
Under Changing Technologies

The Loss, Re-Discovery & Transformation of
a Work Tradition

E. L. Trist, G. W. Higgin, H. Murray and
A. B. Pollock

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INTRODUCTION

The preliminary studies towards this book began over ten years ago in the period, very different from the present, which followed the nationalization of the British coal industry. Expectation then was widespread that management-worker relations would improve and that productivity would increase simply through the change-over from private to public ownership. Such results, however, were not so easily forthcoming. Moreover, men continued to leave the pits though they were needed, and the incidence of stress illnesses at the coal face remained high (Halliday, 1949). Indeed, it was a medical source—the observations of a doctor practising in a colliery district in the interwar period (Dickson, 1936)—which provided some of the first evidence in favour of the general theory of organizational health and work effectiveness which underlies this book.

The view is advanced that the type of work organization conventionally associated with the main persisting form of partially mechanized longwall working contains identifiable socio-psychological features which lead to a number of substandard results: a rate of productivity below system potential; inflated face costs; poor management-labour relations; a low level of job satisfaction; and a high level of worker absence, whether voluntary or occasioned by sickness or accidents. Such a view could be rigorously tested only when, for this same technology, an alternative form of work organization became available, with features which would lead to a prediction of the opposite effects.

Though a number of forerunners of more limited application appeared in the early fifties, it was not until the mid-fifties that a widely applicable alternative emerged. It was the good fortune of the authors to have the opportunity of making a systematic and long-term study of this alternative—in comparison with the conventional organization—in the same seam, in the same neighbourhood, with the same type of equipment and the same type of

Introduction

men. Our findings are that, when the socio-psychological factors involved are thoroughly understood and taken into account, the alternative yields the improvements expected. When they are not, there may be losses rather than gains.

In mining, as in other industries, there is considerable resistance to recognizing that socio-psychological factors are in-built characteristics of work systems rather than additional—and possibly optional—features to do with ‘human relations’. This attitude is one reason why the alternative work method has not been widely adopted.

The advent of mechanization has evoked from the industrial world a rather rigid adherence to a mechanistic theory of organization (Katz and Kahn, 1951). It is likely to be some time before an organic theory is as fundamentally accepted (Shepard & Blake, 1961). Yet, paradoxically, it is the further advance of technology which seems most calculated to bring this acceptance about (Woodward, 1958). Where coal face operations have become comprehensively mechanized, work groups are beginning to establish themselves which have wider autonomy, greater powers of self-regulation, and a fuller commitment to more holistic tasks than those associated with partially mechanized methods. Such characteristics parallel those of the emergent alternative at the level of partial mechanization discovered in this research. They are also the characteristics of pre-mechanized face groups. A tradition deeply embedded in the industry is being re-discovered and adapted to new circumstances.

An understanding of this tradition and the relevance of its application, appropriately transformed, is becoming even more important as mechanization of the industry proceeds—whereas in 1960 under 40 per cent of output was power loaded, by the end of 1961 it was over 50 per cent, and rising steadily.

It may be asked how the tradition came to be lost. The answer can only be that the loss of the more organic type of working group was difficult to avoid given the extent to which an ideology of extreme work breakdown accompanied the introduction of mass-production methods in industry generally. But now that the validity of this ideology has been called into question, much may be learnt concerning the optimum organization of working groups from an industry such as mining. Having always possessed

latent traditions in an alternative direction, it has a creativeness which is bringing into existence models relevant in other contexts.

Of particular interest to the student of social process is the ability of quite large primary work groups of 40-50 members to act as self-regulating, self-developing social organisms able to maintain themselves in a steady state of high productivity throughout the entire period of their 'missions'.¹ These missions, which involved the daily management of a three-shift work cycle by the group itself, lasted for nearly two years—the 'life' of the coal faces concerned. At the end of this time the groups were still growing in their capacity to adapt to changes in their task environments and to satisfy the needs of their members. Autonomous groups of this size are not usually thought capable of succeeding with a task of this complexity or a mission of this duration. The degree of success actually attained varied widely among several such groups studied. Through a comparison, however, of the conditions attendant on these different degrees of success, some at least of the factors crucial for the effective functioning of large autonomous work groups have been identified.

The data on which this study is based could have been obtained only through the prolonged, patient, and intense collaboration of those in the industry, on both the Board and the Union side—at all levels. The relationship of the research team to the men and officials with whom they worked is described in some detail in the text as it is part of the method. We should like here to express our gratitude to them all for being prepared to give so much of their time and interest on the chance that an inquiry by a group of social scientists, about whose disciplines they could have had only the vaguest conceptions, might prove of some use to them as mining people.

The preliminary studies were financed through a grant to the Tavistock Institute of Human Relations by the Human Factors Panel (of the Government's then Committee on Industrial Productivity), which was administered by the Medical Research Council. Subsequent exploratory work was made possible through a grant for the general development of the Institute's research programme from the Rockefeller Foundation.

¹ For the use of 'mission' in this sense cf. Selznick (1957).

Introduction

The main study, 1954-8, in Durham Division, was sponsored by the Department of Scientific and Industrial Research/Medical Research Council Joint Committee on Human Relations in Industry. It was financed at first from Counterpart Funds derived from United States Economic Aid and continued later from United Kingdom Funds.

In addition to the present authors, three former Tavistock staff members took part in the programme: Dr. A. T. M. Wilson, then Chairman of the Institute's Management Committee, was responsible for research policy in relation to the DSIR/MRC Committee and the Divisions of the National Coal Board with whom work was carried out. He contributed both to the fieldwork and to several source papers.

Mr. K. W. Bamforth collaborated in the original study. His experience as a former miner was a stringent criterion against which emergent hypotheses were tested. The pit in which he had worked provided the first example of an alternative to the prevailing work method.

During the main research period, Dr. P. G. Herbst carried out an independent study of a facework group in very great detail and developed a number of new concepts concerning primary group functioning. This study is offered as a supplementary monograph, under the title *Autonomous Group Functioning* (Herbst, 1962).

A second supplementary monograph is also under preparation by one of the present authors, Dr. H. Murray, on the quantitative assessment of composite performance. It has been impossible to do justice in this volume to the mass of material he collected and the systematic methods of treatment he worked out.

This book, which is an overall presentation, is based on a series of source papers by members of the research team. These are listed in the special bibliography and are available for reference through the Tavistock Institute of Human Relations or the Department of Scientific and Industrial Research. In each chapter reference is made to the particular source papers on which the account depends.

Professor Leon Festinger of Stanford University acted from time to time as an external consultant to the research team, visited the collieries in Durham where the main fieldwork was carried out, and gave invaluable criticism concerning the handling of

data. During the preliminary studies Dr. F. E. Emery, then of the University of Melbourne, gave similar assistance.

The final manuscript was prepared by the first author—who has directed the Institute's field studies in the coal industry since their inception—while a Fellow, for the year 1960-61, at the Center for Advanced Study in the Behavioral Sciences, Stanford, California. It expands an earlier report made by Dr. Murray and himself in 1958 to the Joint DSIR/MRC Committee, which was presented to the industry.

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PART I
PATTERN AND PROCESS

SECTIONS

- ONE. *The Nature of the Project:
Methods and Concepts*
- TWO. *Traditional and Conventional
Work Group Organization*
- THREE. *Emerging Forms of Work Group
Organization*

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SECTION ONE

The Nature of the Project: Methods and Concepts

CHAPTERS

- I. *The Socio-Technical Approach*
- II. *Design and Methods*
- III. *The Appraisal of Socio-Technical Systems
in Mining*

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CHAPTER I

The Socio-Technical Approach

THE DEVELOPMENT OF THE CONCEPT

This presentation of research studies by the Tavistock Institute of Human Relations in a number of pits in North West Durham is concerned with the interaction of technological and social factors in industrial production systems—here represented by a variety of mining methods at differing levels of mechanization. The approach adopted, that of considering each production unit as a *socio-technical system*, originated in the first mining study carried out by the Institute (Trist and Bamforth, 1951). The usefulness of the concept having been demonstrated by subsequent work (Wilson and Trist, 1951; Trist, 1953), it has been further developed in two parallel Tavistock projects, one in the Indian textile industry (Rice, 1958), the other the present research. Wilson (1955) has noted that work on similar lines has developed independently in various countries and that similar findings have emerged (Walker & Guest, 1952; Westerlund, 1952; Touraine, 1955).

The propositions underlying the present studies may, following Trist and Bamforth, 1951, be stated as follows: ‘. . . the longwall method will be regarded as a technological system expressive of the prevailing outlook of mass-production engineering and as a social structure consisting of the occupational roles that have been institutionalized in its use. These interactive technological and sociological patterns will be assumed to exist as forces having psychological effects in the life-space of the faceworker, who must either take a role and perform a task in the system they compose or abandon his attempt to work at the coal face. His own contribution to the field of determinants arises from the nature and quality of the attitudes and relationships he develops in performing one of these tasks and in taking one of these roles. Together, the

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forces and their effects constitute the psycho-social whole which is the object of study.'

Rice, in *Productivity and Social Organization*, continues more generally: 'The concept of a production system as a socio-technical system designates a general field of study concerned with the interrelations of the technical and socio-psychological organization of industrial production systems. . . . The concept of a socio-technical system arose from the consideration that any production system requires both a technological organization—equipment and process layout—and a work organization relating to each other those who carry out the necessary tasks. The technological demands place limits on the type of work organization possible, but a work organization has social and psychological properties of its own that are independent of technology. . . . A socio-technical system must also satisfy the financial conditions of the industry of which it is a part. It must have economic validity. It has in fact social, technological and economic dimensions, all of which are interdependent but all of which have independent values of their own.'

It is, of course, the socio-psychological (the people) and the technological (the things) which are the substantive dimensions. The economic dimension measures the effectiveness with which human and technological resources are used to carry out the primary task (cf. Williams, 1950). The importance of the distinctiveness of territory has been discussed by Miller (1959). Emery & Trist (1960) have further shown that the socio-technical concept requires to be developed in terms of open rather than closed system theory, especially as regards the enterprise-environment relation and the elucidation of the conditions under which a steady state may be attained:

'Considering enterprises as "open socio-technical systems" helps to provide a more realistic picture of how they are both influenced by and able to act back on their environment. It points in particular to the various ways in which enterprises are enabled by their structural and functional characteristics ("system constants") to cope with the "lacks" and "gluts" in their available environment. Unlike mechanical and other inanimate systems they possess the property of "equi-finality"; they may achieve a steady state from differing initial conditions and in differing ways. Thus

in coping by internal changes they are not limited to simple quantitative change and increased uniformity but may, and usually do, elaborate new structures and take on new functions. The cumulative effect of coping mainly by *internal* elaboration and differentiation is generally to make the system independent of an increasing range of the predictable fluctuations in its supplies and outlets. At the same time, however, this process ties down in specific ways more and more of its capital, skill and energies and renders it less able to cope with newly emergent and unpredicted changes that challenge the primary ends of the enterprise.' (Op. cit. p. 94.)

Inherent in the socio-technical approach is the notion that the attainment of optimum conditions in any one dimension does not necessarily result in a set of conditions optimum for the system as a whole. If the structures of the various dimensions are not consistent, *interference* will occur, leading to a state of disequilibrium, so that achievement of the overall goal will to some degree be endangered and in the limit made impossible.¹ The *optimization* of the whole tends to require a less than optimum state for each separate dimension.

FOCUSING ON THE SOCIO-PSYCHOLOGICAL SYSTEM

This approach does not imply that in all circumstances a detailed study of all three dimensions must be carried out. It does, however, underline the importance, when any aspect of a production system is examined, of taking into account the manner and extent of its interdependence with the other dimensions. In the present mining studies the research focus is the *socio-psychological* system. It is through the people who comprise this system that technological and economic changes are successfully or unsuccessfully implemented. For such changes to be effectively introduced, understanding of the latent as well as the manifest functioning of the socio-psychological system is necessary (Merton, 1949; Jaques, 1951; Blau, 1955).

The socio-psychological system may be studied at different

¹ Such dissonances between system characteristics may be similar to those described by Festinger (1957) in the field of cognition, though it is beyond the scope of this book to press such a comparison.

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organizational levels in the coal as in other industries: at the level of the individual worker, the work group, the seam, the pit, the Area, the Division, or at the level of the National Coal Board itself, that is, the enterprise as a whole, when a very wide economic, political, and socio-cultural environment must be taken into account. The unit of study on which the present research is centred, however, is the *primary work group*. This is the smallest group whose membership carries out the whole set of activities constituting the unitary cycle of coal face operations. The boundaries of this social unit are defined in terms of the technological unit—the work cycle which it has to perform.¹ Just as the technical system of a coal face forms part of a larger system—the seam—in which it must be integrated for effective working, so does the primary work group—the cycle group—form part of a larger social system. The research is therefore concerned not only with the component work groups at the coal face which make up the cycle group but also with other individuals and groups in the seam population with whom they have immediate relations and who constitute the surrounding ‘seam society’.²

At the level of the cycle group, the technological, economic, and socio-psychological dimensions differ in the degree to which they constrain modification of the system by the group. There is least freedom in the technological system for other than very minor modifications, decisions on the mining side rarely being taken below pit level and frequently involving higher management. In the economic dimension there is somewhat more, though still limited, opportunity for change, as in initiating local negotiations regarding the basis or amounts of payment. Strict account, however, must be taken of the framework of existing agreements, which may be seam ‘prices’ or local colliery settlements; and at an early stage any proposal has to be considered in terms of county and national agreements. It is the socio-psychological system which affords the greatest opportunity for either formal or informal change at the level of the cycle group—in such matters as altering the pattern of work group organization.

¹cf. von Bertalanffy (1950) for the need to represent the mediating boundary conditions (here the technology) among the system constants in order to show how an open system achieves a steady state.

²cf. Lewin (1951) for the importance of adjacent systems both above and below the focal level.

It was not within our terms of reference to consider aspects of the economic system such as the capital, operating, maintenance, and wages costs, or the level of wages or piece-rate prices, as such. None the less, the form of the wages system has considerable bearing on the structure and functioning of the socio-psychological system and in this context is taken into account. Our principal concern is to examine that aspect of the socio-technical whole—the socio-psychological—within which the primary work group has relatively greater opportunity to develop various forms of work organization within imposed technological and economic limits. A set of concepts for describing the socio-psychological dimension is called for, which can be co-ordinated to concepts used in describing the technological.

THE RESEARCH OPPORTUNITY

Over a number of years pilot studies of a variety of mining methods had been made by the Institute in a number of coalfields. Because these studies could be made only as opportunity arose, and because the seam conditions, customs, practices, and attitudes differed in each locality, systematic and detailed comparison of the mining methods was scarcely feasible. Further progress required that these should be simultaneously available for study and that pits using them should be in one Area of a coalfield so as to minimize differences in background and tradition. The opportunity to undertake such studies in an older Area of the Durham coalfield was particularly welcome. In the collieries offered for study there existed—often in the same pit and all actively functioning in the present—a wide variety of mining systems ranging from traditional unmechanized working, through partially mechanized conventional methods, to more highly mechanized emergent systems. Since the faces concerned were in the same low seam, the geological structure of which was noted for its constancy, a comparative study of systems at different levels of mechanization was made possible under conditions more closely similar than any hitherto available.

In the most widespread of the conventional technologies in Durham there also existed two radically different forms of work organization, one of which had its roots in the earlier traditions of

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the coalfield, the other reflecting a form of organization more widespread in manufacturing industries. Comparison of alternative forms of work organization within the same technology therefore became feasible. The hypotheses emerging from the earlier Institute studies made the carrying out of such an 'experiment of opportunity' a matter of central scientific interest.

The co-existence in the present of a historically related range of mining methods, the growing importance of low seams as the higher were exhausted, and the increasing use of more highly mechanized methods in low seams also presented an unusual opportunity to observe, as they occurred, the socio-psychological aspects of technological change.

This book, which covers the period January 1955 to March 1958, presents a general account of the research findings together with a series of field experiments and case studies, full technical accounts of which have been given in the source papers. A description of the design of the research and the methods used is followed by presentation of the concepts developed for the appraisal of work systems. The main mining methods are then examined in these terms, proceeding from the simpler to the more complex and more highly mechanized. In the field experiments and case studies a comparison is made of the operational effectiveness of alternative forms of work organization at the most commonly found level of mechanization. Accounts are given of the social development of composite work groups under advantageous and disadvantageous conditions. Finally, we consider problems of changes in work organization both with and without accompanying technological change.

CHAPTER II

Design and Methods

One of the main problems to be overcome in communicating any work dealing with mining is that of terminology. Each coalfield has its own vocabulary for describing the systems, equipment, and processes of mining, and in the older coalfields, such as North West Durham, many pits use a number of entirely local expressions. Though the N.C.B. has attempted to rationalize the terminology used in the industry, in this account North West Durham usage is followed. So far as possible minimum use is made of specifically mining terms. A guide to mining terminology has, however, been prepared and is offered in Appendix I. Our interest is to develop a set of concepts which relate the technological and the socio-psychological systems. Since we shall be primarily concerned with longwall methods, illustrations of the concepts developed will refer to longwall organization.

SOCIO-TECHNICAL SYSTEMS IN MINING

The mining methods with which we are concerned have one characteristic in common—all are *cyclical* systems in which a sequence of operations has to be carried out for each 'web' of coal that is extracted. They are to be distinguished from more recently developed *continuous* methods in which operations are carried out simultaneously rather than successively so that a relatively steady flow of coal emanates from the face during all shifts. In cyclical systems, three phases of the production cycle may be identified:

- (a) *preparation*, in which operations are directed towards making the coal more accessible and workable
- (b) *getting*, in which the coal is loaded and transported away from the face

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- (c) *advancing*, in which roof supports, gateway haulage roads, and conveyor equipment are advanced.

Depending on the type of technology, these phases comprise a varying number of operations of different duration which only to a limited extent overlap in time.

The character of socio-technical systems is related to level of mechanization. As in other industries, mechanization in mining has proceeded from the introduction of power driven tools which aid the miner towards the introduction of more complex machines which he services and controls. Systems vary not only in level of mechanization—the proportion of effort coming from non-human sources—but in the evenness and comprehensiveness of the mechanization of their component parts.

In the simplest form of traditional mining each work place comprises a small separate coal face and is occupied by one miner at a time, although the place itself may be shared by two or three men, each of whom works on a different shift. The coal is won by hand picks and removed from the face in tubs. Various patterns of laying out the faces for working a seam are to be found. These methods—bord and pillar, rib and stall, gateway and stepwise longwall—are similar except for layout and can, so far as work organization is concerned, be treated as one type, and referred to as *single place working*.

The advent of *face conveyors* led to the introduction of *longwall conveyor working*. On these straight faces, 80-120 yds long in this part of Durham, coal was originally won, as in single places, with hand picks and then filled (shovelled) on to a face conveyor running along the now continuous coal face and discharging into tubs in the gate. The later introduction of pneumatic picks, both in single places and on hewing longwalls, raised the level of mechanization a further step. Another variant of longwall technology which raises it still further is the use of electrical coal cutters and shotfiring to prepare the coal for loading by hand. Of these two variants of partially mechanized longwall conveyor mining, cutting longwalls are the most widespread in Durham and throughout Great Britain, whereas hewing longwalls are peculiar to Durham and one or two other areas. This predominance of cutting faces arises because most of the coal is rather hard and at the same

time most of the seams are fairly level. On the European continent hewing faces are more common as much of the coal is both relatively soft and in heavily faulted areas. In the United States continuing availability of thick seams near the surface has led to the mechanization of bord and pillar layouts in shallow mines and drifts.

Conventional longwall organization has developed on the principle of 'one man—one job', but an alternative form has emerged on some hewing and cutting faces which has its origins in the single place tradition. This is known as *composite longwall* working in which there is no rigid division of labour as on conventional faces.

Mechanization of conventional longwalls began in higher seams with the preparation and, to a lesser extent, with the getting phase. Relatively simple methods for power-loading prepared coal are now also becoming more widespread in low seams, and more advanced methods have been introduced which combine the preparation and getting phases of the production cycle. At the present time further mechanization is taking place by the installation of power-assisted methods for advancing face conveyors, roof supports, and gateways.

THE EXPLORATORY PHASE

The initial conception of the research, based on outline information about the methods of working in the pits offered for study, was to compare, within a single seam, earlier traditional methods with conventional longwall working in both its hewing and cutting forms, and with forms of this latter containing elements of higher mechanization. Divisional and Area executives felt that the results obtained from increasing mechanization were far from always up to expectation and wondered how far the reasons might lie in the socio-psychological field.

One of the main starting assumptions was that a single seam of coal would be sufficiently similar at different pits to make possible direct comparisons of the results obtained by different methods of mining. It was found that, despite its reputation for general consistency, conditions in the selected seam—the Manley¹—were not physically identical in the way hoped for. Certain geological

¹ The names given to coal seams are fictitious.

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variations were present in each pit, which, though slight in themselves, had been decisive in settling the method of mining. There were also differences in the seam systems in which the various face units existed. These were to some extent technological, as for example the nature of the haulage facilities; but there were more general differences such as phase of development, scale of operation, and degree of homogeneity-heterogeneity in methods of facework. While such factors added to the difficulties of making direct comparisons between face units, their early elucidation substantially increased the reality of research plans. It became even clearer than had been anticipated that the cycle group of each face must be studied in relation to seam organization, for what was being done with the seam as a whole from the mining point of view greatly affected the psychological climate—and technological conditions—at particular faces.

During the exploratory phase other parts of the designated pits were visited to gain, for comparative purposes, familiarity with conditions elsewhere than in the selected seam. It was realized in this way that it did not so much matter whether a face was in one seam or another so long as the project was kept within the kind of low seam conditions generally prevalent in the Area, which the seam originally selected typified. This is because in longwall working seam height affects face length and this, in turn, the size of the working group. In higher seams visited during previous studies faces had been much longer and groups altogether larger than those now found. This makes the longwall system under high seam conditions a rather different world as regards group relations from that encountered in the present study—and even more difficult.

The general aim was restated as the comparison from a socio-psychological viewpoint of certain methods of mining under low seam conditions. While residual variations in geology and in operational background might prevent the simple direct comparisons of performance originally envisaged, the selected seam offered the best available example of what happened to work organization and group relations under low seam conditions. The development of valid methods of comparing performance became a problem to be resolved during the research. The methods developed are stated in Chapter XII.

DESIGN

As the study progressed, certain modifications were introduced into the original programme of pit visits so that a better design could be obtained. Work was undertaken at five pits, which between them provided three examples each of single places, hewing longwalls, cutting longwalls, and more highly mechanized faces. In one of the pits both conventional and composite forms of longwall organization were available for study.

The overall design involved the intensive case study, both qualitative and quantitative, over an extended period of time of the structure and functioning of the social system associated with at least one example of each of the main mining methods. Less intensive studies were made of other examples of each system but no attempt was made to conduct a 'sample survey', for it is not in this way that one can discover how a system works or changes over time. The period of work immediately following the exploratory phase was directed towards the elucidation of a set of concepts which would permit comparison of the different systems, and identification of those aspects of each which merited fuller consideration.

The research was conceived as falling into four main sections:

- (a) A background study of the types of group associated with unmechanized pre-longwall mining—single place methods of working—represented by bord and pillar and rib and stall layouts.
- (b) Comparison of conventional and composite methods of longwall organization on:
 - (i) hewing longwalls
 - (ii) cutting longwalls.
- (c) Problems associated with the conversion of faces from pre-longwall and conventional organization to composite methods:
 - (i) from bord and pillar to composite hewing longwall
 - (ii) from composite cutting shortwall to composite cutting longwall
 - (iii) from conventional to composite cutting longwall.
- (d) The effects on cutting longwall organization of further mechanization:

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- (i) single task machines, e.g. flight-loader, scraper-packer
- (ii) multiple-task machines, e.g. multi-jib cutter, Haarman scraper-peeler, tension-chain scraper.

SANCTIONING THE PROGRAMME

Following a request in August 1954, to the Chairman of the Durham Division, N.C.B., for an informal discussion concerning the granting of research facilities, a meeting was held at the Divisional Headquarters at which agreement was reached that work should go forward in the Division. A particular Area¹ of the Division was selected for study and a general research plan drawn up. A further meeting was held in November 1954, at which sanction for the research was given both by the Chairman of the Division, and by the General Secretary, National Union of Mineworkers, Durham Area.² The Institute then met the Area General Manager, his staff and pit managers to discuss in detail the proposed research methods and programme.

The initial procedure followed at every colliery was as follows. The colliery manager met the secretary and other officials of the local N.U.M. branch (lodge) to outline the purpose of the research and to inquire whether the lodge would agree to fieldwork being carried out at the pit. A full meeting of the Colliery Consultative Committee was then held at which the Institute outlined project objectives, research methods to be used, and procedures to be followed in reporting back results. It was agreed that detailed reports on work at particular pits would be submitted for comment to the Colliery Consultative Committee before being passed, on the N.C.B. side, to the Area General Manager and the Divisional Chairman and, on the N.U.M. side, to the General Secretary, N.U.M. Durham Area. It was further agreed that any more general report would be seen by these latter executives, before being discussed as regards general publication with the National Coal Board in London. This procedure would ensure that all reports would be accurate as regards matters of fact and

¹ For purposes of both technical planning and general management collieries are grouped geographically into Areas, which contain about 20 collieries, although this number varies greatly according to the size and dispersion of the collieries involved.

² On the Union side an Area is equivalent to a N.C.B. Division.

non-prejudicial to the interests of the Board and the Union, while the views expressed and the interpretations made would be those of an independent research team.

METHODS

Fieldwork was conducted by observation at the coal face on all shifts and by interviews with key informants at all levels from workmen to managers. Underground visits lasted from four to seven hours. The first objective was to gain an understanding of the technology and of the customs and traditions. On initial visits to a face we were introduced by both a senior management representative and a union official. During the subsequent visits, as far as possible, a different guide was provided on each occasion, sometimes from the union, sometimes from management. In later phases, when the research team had become at home with the geography, safety rules, and customs of the different pits, members were given the normal written authority of the pit manager to travel unescorted.

Although the men on the faces were aware of the general nature of the research, the first period constituted a phase of testing out the research team. We were questioned closely about the reasons for the research, the level of sanctioning, and the source of financial support. Once the face teams accepted that the research was not being carried out on behalf of either management or union, but was an independent scientific inquiry and that the results would in the first place be reported back to those directly concerned, discussion of 'private' rather than 'public' attitudes and opinions (Katz and Schanck, 1938) about systems of work became possible. From what the teams told us during these early visits of their attitudes towards 'official' research, effective rapport would not have been established had any attempt been made to take notes at the coal face. The practice was therefore followed of making tape recordings from immediate recall following each underground visit.

One research team member assumed responsibility for maintaining relationships with the team of each working face, observer reliability being ensured by independent visits from other members and by concurrent visits of pairs of fieldworkers. The validity

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of facework observation was assessed by the method of predicting the activities at one part of the face from a knowledge of what was going on in another, and then checking the predictions. Because of restricted visibility and mobility under low seam conditions, this is the only feasible way of obtaining a valid account of a system in operation. As observations became more elaborate and a greater understanding of the system was achieved, the provisional descriptions and conclusions were discussed informally with the men concerned to ascertain whether a true account had been obtained. By following this procedure of repeated delayed playback the research team became aware of on-going changes in work organization. Events were uncovered in this way which had been regarded as too insignificant to mention, but which were of key importance for understanding the system.

Although all our informants were interviewed at the coal face, a number were also seen, individually or in groups, in rooms at the miners' lodge. The men were unfamiliar with this kind of situation, and such methods proved unproductive. They were discontinued in favour of less formal contact in men's homes and in local clubs and pubs.

Full access was given by management to the standard pit records dealing with production, attendance, sickness, absenteeism, etc., and to the various statutory reports prepared by colliery officials. For some aspects of the research, use was made of specially devised record forms which were completed by deputies and team captains.

Although the general pattern of the research became established at an early date, the unpredictability both of conditions at the coal face and of management-lodge relationships made it impossible to follow a programme predetermined in detail. The research team had often to await the resolution of circumstances beyond their control and be on the alert for opportunities not envisaged when plans were drawn up. Particularly was this so in pits in which technological changes were introduced, or in which the system of work organization was being altered.

Without the complete co-operation of both management and union the research would not have been possible. In fieldwork of this type a research team is more than usually dependent on the help and guidance of those with whom they work. The increas-

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ingly open manner in which problems were discussed and the readiness of face teams to throw light on matters which would not in other circumstances have been disclosed were essential conditions on which obtaining the primary data depended.

CHAPTER III

The Appraisal of Socio-Technical Systems in Mining¹

PRIMARY TASK

The concept which integrates the technological, economic, and socio-psychological aspects of a production system is the *primary task*—the work it has to perform (Bion, 1950; Rice, 1958). Work in this sense is the key transaction which relates an operating group to its environment and allows it to maintain the steady state (Emery & Trist, 1960). The production system with which we are concerned is the coal *face system*, although as indicated in the previous chapter this must be studied in the context of the larger *seam system* of which it is a part. The primary task of a face system engaged in three-shift longwall working is the daily completion of a production cycle under all the given conditions that prevail.

THE UNDERGROUND SITUATION

The underground situation can vary greatly from one face to another and from one type of system to another, but common to all is the absence of fixed and consistent conditions in the physical environment. The complex of factors affecting work at the coal face is of the kind that would confront a factory if productive machinery had to be moved and re-set every day; if every operator had to contend with constant minor changes in the material he was working on; and, at the same time, look to keeping the walls and roof of his work area supported because they were imminently liable to collapse; if all supplies had to be

¹ Source papers: 18, 20, 22, 23.

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brought in and products removed through two narrow passages; and if, despite the absence of uniform working conditions, supervisors could visit the operators only occasionally throughout one shift. Unlike the factory situation, where a high degree of control can be exercised over the production process since working conditions can be maintained in a passive and constant state, in the underground situation the threat of instability from the environment makes the production task much more liable to disorganization. Under the dangers, stresses, and difficulties of the underground situation, certain qualities, evolved from the experience of successive generations and characteristic of traditional mining systems, are especially appropriate for the organization of work groups:¹

- (a) acceptance of responsibility for the entire cycle of operations
- (b) recognition of the interdependence of one man or group on another for effective progress of the cycle
- (c) self-regulation by the whole team and its constituent groups.

How far a work group is capable of such *responsible autonomy* and is able to adapt itself in correspondence with changing conditions indicates the extent to which its social structure is appropriate to the demands of the underground situation. The concept of responsible autonomy introduced by Trist and Bamforth in their original study of longwall in relation to traditional systems is intended to summarize these requisite² characteristics.

ACTIVITY STRUCTURE

Analysis of the activity structure in these terms is basic to an understanding of work group organization—the way in which those who carry out the necessary tasks are related to each other. Although the technology places limits on the kind of work organization possible, it does not uniquely determine its form, which may be analysed in terms of the five following aspects, each of which is more fully considered in subsequent paragraphs:

- (a) the quality of the *work roles* to which each system gives rise through the division of labour

¹ cf. Gouldner (1954).

² For the term 'requisite organization' *vide* Brown (1960).

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- (b) the kinds of *task group*—the groups who together carry out given operations at the coal face and share a common pay-note
- (c) the *work culture*—customs, traditions, and attitudes—which governs how these groups are built up and conduct themselves
- (d) the nature of *inter-group relations* between task groups making up the face team
- (e) the *managing system* through which the work of all faces in the seam is supervised, supported, and co-ordinated.

WORK ROLES

In analysing any mining system, or in comparing one with another, the first consideration is to make a systematic examination of work roles. By work roles are meant the jobs which people do every day and with which they become identified—cutters, fillers, pullers, stonemen, etc. In thinking of themselves as such they gradually take on certain common characteristics and may be said to acquire the *character* of their role. In an industry such as mining, the role with which a man is identified becomes a way of life. Work roles vary both within and between mining systems, in their nature, their quality, the demands they make upon their occupants, the satisfactions they afford, and the degree and type of stress to which they expose those who carry them out.

A work role—what a man does, where, when, and with whom—is primarily determined by the formal division or allocation of the tasks constituting the cycle of operations among the men who form the cycle group. A distinction must, however, be made between the formal or specified work role (the 'model') and the actual role which develops under a particular set of operating conditions. This distinction between formal and informal functioning applies also to other aspects of the social system. Recognition of such differences may not only indicate the efficiency of system functioning but also point the direction in which explicit technological or social change may profitably develop to achieve a better fitting together of the different aspects of the system as a whole.

A formal work role usually constitutes a main task together

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with such sub- and ancillary tasks as are associated with it. Since in certain systems the shifts on which main tasks are carried out are fixed, it is meaningful to talk of *task-shift roles*. According to the system of organization, tasks may or may not be specific to particular roles. The range of tasks and shifts comprising a work role may be narrow or wide depending on whether there is formal *rotation of shifts and tasks*. The *task range* of a role may also be increased by disorganization, as when the work a man normally does becomes unavailable because of cycle breakdown and he is required to undertake activities properly belonging to another role. The delineation of work roles is, therefore, to some extent a function of the period of time over which the role content is observed.

The task content of work roles must also be examined in relation to the level of skill involved, a consideration of importance where questions of degree of specialization or interchangeability arise. How far the activities of a role comprise a self-completing whole task which occupies a full shift or how far the man has to fill out part of his shift by undertaking other activities has bearing on the extent to which he can experience satisfaction and identify himself with his role. In work systems where there is a large number of different work roles, some, because of the position they occupy in the cycle, may gain in status, power, and reward at the expense of others, to a degree which is disproportionate to any real difference in skill and effort.

All roles at the coal face are stressful, but the pattern varies with the different roles. The physical effort required, the liability to interference from factors beyond the control of the facework group, the cruciality of the tasks for cycle progress, the monotony or variety of tasks, the permanency of the roles and the shifts on which they are carried out, are all factors which contribute to the *stress pattern*. When conditions become bad, certain roles are more exposed than others so that undue stress falls on those concerned. Casualties arise if there can be no relief. The pattern of absence, accidents, and sickness is, therefore, relevant in an examination of work role stress.

TASK GROUPS

The whole team of men responsible for the operations of a particular unit is the *cycle group*. This is sometimes referred to as the 'face' or 'panel' team. In any seam, the cycle groups, together with the other piece and datal workers in the seam, constitute the *seam population*, which includes the younger men who are aspiring to facework, as well as older men who have retired to jobs away from the coal face. Depending on the system of working and the form of organization, the cycle group may contain a number of distinct sub-groups. Where the cycle of operations is spread over more than one shift, there will be different *shift groups*. If a production unit has two faces—a double unit—there may be two *face groups*.

A group of men carrying out a particular operation in a particular location on the coal face is referred to as an *activity group*. These groups may vary in size—according to the particular activity or activities carried out—and in the kinds of relationships between the men constituting the group. According to the system of work organization, the membership may be permanent or may vary, systematically or otherwise. Those activity groups which share a common paynote, and in which membership is permanent, are referred to as *task groups*.

Task groups, which are the basic units in a study of facework organization, vary in size and differ according to the kind of relationships the men have with each other in the work situation. In *identical role* groups all concerned are supposed to do the same amount of the same task and work more or less independently of each other. In *reciprocal role* groups the interdependent component activities of a main task are shared out among two or more persons who work together in order to complete it. There are also task groups of one, *isolate roles*, in which a man carries out a main task alone. The first step in the analysis of the characteristics of each task group is to determine the extent to which the structure of the task places limits on the kinds of relationship that are possible between the men in the group—whether work may be carried out independently or in sub-groups of two or three; whether the level of skill or effort required is the same for all

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members of the group; whether or not stress arising from the task is likely to affect all members equally, etc.

WORK CULTURE

For a fuller understanding of the behaviour of facework groups—whether cycle, shift, face, activity, or task—it is necessary to examine the pit and seam *culture*—the customs, traditions, and attitudes which regulate how men achieve membership of the various groups and conduct themselves as group members. In the underground situation of high risk, self-dependence and the good use of discretion are necessary. It follows, as was pointed out at the beginning of this chapter, that to a considerable degree face groups must be autonomous and self-regulating. This can only come about if groups develop customs and traditions for regulating their behaviour and relationships which are internal to themselves and binding by force of the authority of the group itself. The psychological climate of a group and the kinds of relationship it has with other groups involved in completing the same primary task is to a considerable degree determined by the way in which the groups are built up. It is important to determine the route through which men achieve membership of particular groups, the permanency of membership, and the route by which men leave. To do this an examination must be made not only of the various facework groups, but of the wider seam population. The earlier history of the seam has to be examined in order to gain an understanding of the way in which some of the on-going pit customs and practices have evolved.

INTER-GROUP RELATIONS

In longwall working especially, the various task groups need some system of inter-group relations to enable them to co-operate successfully in the overall task of cycle completion. An appraisal must, therefore, be made of the way in which task groups are related to each other and the extent to which their activities and attitudes facilitate or hinder completion of the overall goal. The *degree of segregation* of the various task groups comprising the cycle group, their number, and work relatedness to each other

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determine the basic pattern of inter-group relations. Within task groups there may be a number of activity groups whose membership may or may not be permanent. Role allocation may be to varying degrees flexible. At one extreme are fixed roles, at the other systematic patterns of rotation; in between are *ad hoc* exchanges of jobs. The extent to which all members of a cycle group share a common experience must be examined in relation to the way each constituent group carries out its work, since this can affect the conditions with which later groups have to cope.

The technological interdependence of activities is such that task groups are to varying degrees dependent on preceding groups. A situation of this kind tends to give rise to differences in status and power—according to the relative independence of a group's work and its cruciality for cycle completion. Where differences in status and power arise they may be reflected in differences in the level of earnings. It is in this connection that account must be taken of the way in which the payment system operates. The earnings of a group may be dependent to varying degrees on completion of the overall cycle task, on completion of its own main task, on the efficiency with which preceding groups carry out their tasks, and on the amount of unpredictable interference with their work arising from causes beyond the control of the cycle group. When the earnings of one group are too greatly dependent on the skill and attitude to its work of another, conflicts may arise and a state of tension develop between successive groups. As a protective measure against loss of earnings caused by the inability to complete main tasks regularly, groups may also, wittingly or unwittingly, go into collusion to carry out work in ways which, though economically mutually advantageous to the task groups concerned, may militate against the efficient completion of the production cycle.

THE MANAGING SYSTEM

Because main task groups share work places and equipment on successive shifts, overall co-ordination and continuity are required for smooth running of the *face system*. This is provided by the managing or governing system—which includes the total means adopted to maintain the boundary conditions of given 'operating

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systems'.¹ These must be examined not only at face level but at the level of the seam. The *seam system* includes the face systems together with their common *service system* which covers everything supporting the productive operations of faces—transport facilities for coal and supplies, communications, manpower reserves, repair work, development work, etc. The formal managing system of the seam embraces the deputy, overman, and undermanager—officials who are external to the face team; but some co-ordinating and regulating functions may reside within the face team and its constituent groups. These may sometimes be carried more or less explicitly by 'team captains'.

Important for a differentiation of systems of work organization is the extent to which co-ordination of task groups is *internal* or *external*—is carried out by the cycle group itself or effected by management external to the face team. Specific activity and task groups may be internally self-regulating without accepting responsibility for co-ordinating themselves as a shift group. Shift co-ordination may be provided entirely by the deputy who, when his shift overlaps others, also provides continuity between them. It is, therefore, necessary to identify the level at which responsibility is taken for co-ordinating the cycle group as a whole and the means by which this is done.

Since at any time the progress of operations on a face may be affected by what is happening in other parts of the seam system, each face 'shift supervisor'—the deputy—must be related to the seam 'shift supervisor'—the overman—whose responsibilities vary according to which shift he is on and the character of the seam system. It is at the level of the undermanager that the two facets of seam management—co-ordination of the cycle of operations on each face and co-ordination of the seam system on all shifts—become the responsibility of one person. An examination of the managing system at each level in the seam must explore the way in which information is generated, received, and transmitted, the kinds of decisions that have to be taken, the means by which they are implemented, and the nature of the stresses and strains to which officials are exposed. At the deputy and overman levels in particular, which are usually filled by promotion of qualified men from the face, conflicts may be experienced between the pressures

¹ Rice and Trist, 1952; Rice, 1958.

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of tradition and custom on the one hand and the technological and economic demands of higher management on the other. The nature of these conflicts and the habitual methods of coping with them must be ascertained. Finally an attempt must be made to assess, in terms indicated in the earlier paragraphs of this chapter, the extent to which the managing system functions so as to enable the production units to carry out their primary task under the ever-present difficulties of the underground situation.