EUROPEAN COAL AND STEEL COMMUNITY

Community Ergonomic Research

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Source : Ergonomic team of the Netherlands coal-mining industry
Project n° 2

Authors : Dr. G.B.M.L. KOENE, L. RUWETTE

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European Coal and Steel Community

COMMUNICATION AT THE COAL FACE

Empirical study of an ergonomics approach

Introduction

The problem of underground communication at the coal face has been recognized for many years. It arose again in connexion with a study of the workload on the hewer and overman. The work study experts responsible for this research were faced with the problem of communication at the coal face.

The techniques available to them for estimating workload took little or no account of the psychological aspects of this communication problem. Their physiologically oriented method only allowed them to measure the physical movement necessary for normal communication. The results therefore showed no clear distinction between the functional requirements of the hewer and overman. It was apparent to the work study experts that communication took place under difficult conditions at the coal face. One of the overman's important tasks is to ensure proper reporting at the face. To exercise his supervisory duties, the overman requires a great deal of information; he must also be able to transmit messages and instructions over some distance. Faced with this communication problem, the ergonomists felt it necessary to arrive at a more satisfactory solution.

Personnel working underground in coal-mines who have been confronted with this problem for many years have now learned to live with it. At the time of our research, the mine workers were no longer immediately concerned with this matter. But the communication problem has not been and never will be altogether satisfactorily solved. Many difficulties have to be overcome every day and relegate the communication problem to the background. As an ever-present complication, it is no longer consciously perceived.

However, the pit management and supervisors were amenable to a reexamination of this problem with a view to its solution.

The proposed solution consisted in the installation of loudspeaking telephones (1).

Financial support from the ECSC was decisive in enabling a proposed experiment to be carried out.

If an attempt on these lines to improve a work situation is to be described as an ergonomics project, it is essential for practical data to be systematically collated for proper evaluation of the measures adopted.

This report contains detailed account of the procedure followed and observations made in our study.

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(1) An experiment with the W.L. 20 intercom system, manufactured by Funke and Huster, was envisaged.

CHAPTER I: SYSTEMATIC STUDY OF COMMUNICATION AT THE COAL FACE (1)

Discussions with the overmen and observation of their work showed how important it was for them to have accurate and detailed information on activities at the coal face. They must move around the coal face a great deal in order to acquire this information. But these movements are often made under difficult conditions; the acquisition of information with a view to taking decisions therefore entails considerable physical stress.

Acquisition of information and reporting

Information is acquired and reported at the coal face in a variety of ways.

1. First there is the panel telephone. Telephone sets are installed at the top and bottom ends of the face. In addition communication can be established from these sets with the loading points in the supply and loader gates, with the telephonist-traffic controller's central station and with the superintendent's room. Communications are established automatically by dialling.

2. A coal face telephone is also available. Telephone sets are installed at the top and bottom ends of the face and at a number of points on the actual coal face.

The call signal is transmitted by the coal face lighting.

The lights are switched off and on three + four times (3 x + 4 x) to call a man to the telephone. One disadvantage of this system is that it may be necessary to walk a considerable way to answer a call.

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(1) The study was conducted in panel U^2, seam XIX, district 435 of the Emma-Hendrik pit, of the nv Nederlandse Staatsmijnen/DSM.

In addition, the light signal does not indicate which particular telephone should be answered or the person for whom the call is intended.

3. The coal face lighting is one of the main means of communication at the face. Messages can be transmitted by switching the lights off momentarily.

These messages are coded.

The following signals are used on coal faces equipped with a chain conveyor:

lights off once:	stop everything
lights off and on 4 + 2 times:	conveyor forwards
lights off and on 4 + 3 times:	conveyor backwards
lights off and on 4 + 4 times:	end of shift or meal break
lights off and on I+I+I+I+I+I+:	repeat signal

On coal faces equipped with a coal plough:

lights off and on once:	stop plough
lights off and on twice:	raise plough
lights off and on three times:	lower plough

Special signals:

general alarm signal: lights off and on five times + lights off once
alarm signal cancelled: lights off and on five times + twice
call signal for coal face telephone: lights off and on three + four times

4. Finally messages are also transmitted verbally for man to man at the coal face. Here there is a risk that reports may be distorted At coal faces on which foreign workers who do not have a sufficient knowledge of Dutch are employed the message may be completely lost.

Systematic definition of the overman's activities

After detailed observation of the general working situation, the activities of the overman and operator at the bottom end of the coal face were recorded minute by minute throughout a morning and afternoon shift. For this purpose three persons made detailed observations of the two overmen and operator. They noted the position of the overmen whenever they intervened. Their notes were then collated in tables (see annexes I and 3).

These tables show the moments at which the two overmen, the operator at the bottom end of the coal face and where appropriate other persons received or transmitted messages, instructions or communications. The distance over which the communication took place varied.

The time of communication is shown in graphic form (↗) in the figures contained in annexes 2 and 4. The position of the overmen at each moment is also indicated in these figures.

The operator of course remains at one specific point, i.e. the bottom end of the coal face.

The figure in annex 2 relates to the morning shift and that in annex 4 to the afternoon shift. The time is shown on the X-axis and certain fixed points on the coal face indicated by the scraper cylinder numbers on the Y-axis. The distance between the scraper cylinders was 6 m. The total length of the coal face was about 240 m. The connections for the coal face telephone were situated near cylinders 9, 20 and 31.

Notes on the systematic observations

Closer examination of the detailed record of the time at which communications were established shows that the overman is often in a state of uncertainty. Why has the plough stopped ?

Why and where has an alarm signal been actuated ? Has the necessary action been taken to remedy the fault ? There are dozens of questions to which he often only receives an answer after some time. This regularly obliges him to move around the coal face even more than would normally be the case and these movements are extremely difficult since the seam opening is only about 1 m high.

Surprisingly often the overman is obliged to ask why the chain conveyor and plough have stopped. The stoppage can of course be observed at any point on the coal face. But the supervisor does not generally know the reason for it. It may take valuable time to obtain the necessary information.

Until the cause of a fault has been clarified, it is not possible to take remedial action. The lack of proper communication prevents flexible adaptation of activities at the coal face as a whole to unforeseen circumstances. It is surprising how few decisions the overman actually transmits. In order to obtain sufficient information he must himself go to the point involved. Under these conditions, the supervisory function must be shared between two overmen.

The figures in annex 2, and especially annex 4, show that the overmen spend a relatively long time in the vicinity of the coal face telephone.

Previous observations had already clearly shown that the overmen attempt to choose the most favourable position for communication. This observation is confirmed by the graphic representation of the systematic observations in the figures contained in annexes 2 and 4.

CHAPTER 2: THE INSTALLATION OF A LOUDSPEAKING TELEPHONE AT THE COAL FACE

The systematic observations described in chapter 1 showed that communication between the supervisory staff and personnel was inadequate. The information available to overmen was particularly deficient. For example they have insufficient information on the reasons for stoppages.

They are therefore not in a position to take rapid decisions. Because of the need to go frequently to the place of breakdowns to observe the situation for themselves, their range of action is limited.

The systematic observations confirmed recognized facts. The work study experts once again drew attention to the importance of the communication problem. Systematic observation then clearly revealed the deficiencies of the communication network.

The management was particularly impressed by this clear picture of the shortcomings in communication. The experts' report found an all the more willing audience in the management as it was accompanied by a proposal for possible improvements.

An improvement in communication can only be brought about by making information available at any point on the coal face on all occurrences affecting the face as a whole. In addition provision must be made for transmitting messages from any given point to any other point on the face.

A loudspeaking coal face telephone was seen as a possible solution to these requirements.

The ergonomics team proposed to the management of the Emma-Hendrik pit that coal face U^2 should be equipped experimentally with a Funke and Huster W.L. 20 intercom system.

The W.L. 20 loudspeaking intercom system

The W.L. 20 intercom system consists of a series of combined loudspeaker and microphone sets which can be installed at regular intervals in the coal face on the conveyor supports.

Each set incorporates two loudspeakers and a microphone. Pressure on the microphone button is sufficient to transmit a message through all the loudspeakers installed on the coal face. A push-button on each set also enables whistle signals to be transmitted if necessary. All the loudspeaking telephone sets are powered from a central source. In the event of failure of the supply current, the installation can remain in service for a considerable time since each set incorporates an accumulator.

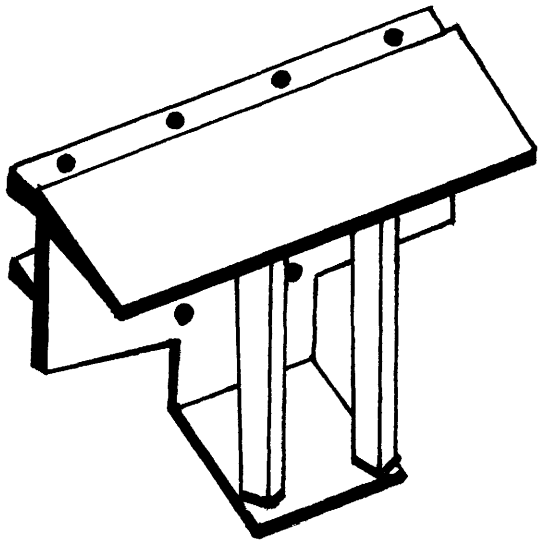
The range of the loudspeakers is normally about 10 m on a coal face.

It is therefore sufficient to install a set every 20 m for a communication to be heard at all points on the face.

No member of staff is ever more than 10 m away from a set from which he can transmit a message. The figures in annexes 5, 6 and 7 show the loudspeaker/microphone set.

A number of technical improvements were made to the original installation. To begin with a protection cover was designed to guard the unit against falling rocks.

This device is illustrated below.



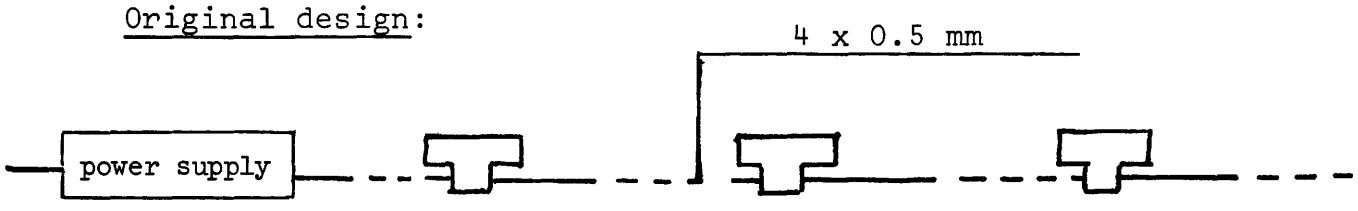
A detailed design drawing will be found in annex 8.

The microphones in diecast aluminium were replaced by plastic microphones.

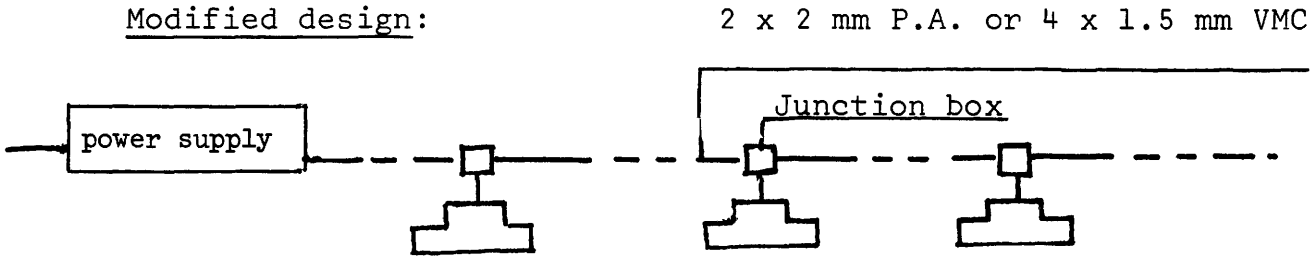
The permanent connections between the cables and loudspeaker/microphone sets were slightly modified.

The continuous line running between the loudspeaker sets was equipped with junction boxes and the original 4 x 0.5 mm cable replaced by the better protected 2 x 2 mm pliable armoured cable or 4 x 1.5 mm vinyl mantle cable.

Original design:



Modified design:



Introduction of the loudspeaking telephone

After first connecting up part of the equipment above ground and giving appropriate instructions, the communication system was installed in a coal face and brought into service.

However, commissioning of the telephone system was not without problems.

Technically there was little difficulty but problems of a social and psychological nature arose.

The first difficulty was to overcome a certain timidity in use of the apparatus. A great deal of attention was therefore given to the instruction phase.

The aim was to persuade personnel rapidly that they were dealing with an ordinary electronic aid which they should use freely. The fact that the panel management made ostensible use of the equipment proved a great help. This means of communication at the coal face was also repeatedly used by the pit engineer which helped to accustom all the personnel rapidly to the new device.

The attitude of the management and supervisors had a decisive influence. This is confirmed by the fact that installation of the system in another coal face after the experimental period proved more difficult; it had been prepared less carefully and the instructions had been more cursory.

In the first instance constant psychological support had helped to eliminate difficulties during the experimental period. But the fact that this result was due precisely to these back-up measures was not sufficiently recognized. A radically new aid of this kind must be introduced with great care and above all used with discipline.

Once the problem was recognized, introduction of the loudspeaking telephone in other coal faces was preceded by a detailed instruction programme for the benefit of all the staff.

The social and psychological experience gained during the experimental period should perhaps be described in more detail.

In general it may be stated that the loudspeaking telephone makes communication at the coal face so public that this factor must be taken into account. In the first place this means of communication requires a greater control of language. Criticisms or negative remarks can be heard by all the personnel at the face. This makes the supervisors' task more difficult.

In addition, a convenient means of communication makes it easier for supervisory staff to intervene when a lower-ranking official has already given an instruction. Caution is necessary so as not to interfere with the hierarchical structure; failure to exercise the necessary caution may undermine the authority of lower-ranking officials. In general, tactical mistakes have wider implications because communication is more public.

Experience shows that there is a temptation to transmit messages appealing to the "sporting" sense of personnel and encouraging them to work harder.

Once the personnel realize that messages of this kind are not entirely realistic, they no longer take subsequent messages seriously. In a system where messages are passed from man to man, there is some possibility of social control for the first persons in the line of communication.

Supervisory staff are then not so open to the temptation of transmitting messages of the type described above.

Another error which was often committed initially was to use the loudspeaking telephone in the same way as a normal telephone set. It is sufficient for a message intended for a given person to be heard by him. But to begin with, the person concerned was often asked to reply. He had to interrupt his work and go to a telephone set to give his reply. This procedure is particularly troublesome and must be avoided whenever possible.

Situations of this kind frequently arise in the event of stoppages. The official responsible then tries to remedy the breakdown as soon as possible. He may consider questions from supervisors regarding the duration of the stoppage as a hindrance and the need for him to go to the microphone to answer a question prolongs the duration of the stoppage.

Finally, the greater ease of communication is a temptation to supervisory staff to try to obtain fuller information than is in fact necessary for proper conduct of operations.

CHAPTER 3: COMMUNICATION AT THE COAL FACE AFTER COMMISSIONING THE LOUDSPEAKING TELEPHONE SYSTEM

Once the loudspeaking telephone system had been in use for a few weeks, a new study was made of communication at the coal face. Previous observations had suggested that the new installation would facilitate communication to such an extent that one overman could easily do the work for which two had been needed before. An experiment with a single overman for the whole coal face was therefore envisaged. This measure did of course entail organizational changes which were liable to influence the experiment unfavourably. On the other hand it might be even more difficult to reduce staffing to a single overman later on. For purely pragmatic reasons, it was therefore decided to go ahead with the experiment after full consideration and detailed discussion with the management.

Use of the loudspeaking telephone system

It appears desirable at this stage to make a few general observations on the use of the loudspeaking telephone after it had already been installed for some time.

A more systematic study will be described later.

The apparatus appears to be used primarily when stoppages occur. The persons concerned at the coal face know the reason for the stoppage almost at once. A report can be given on the situation from the very place at which the stoppage has occurred.

If the cause of the stoppage lies elsewhere than at the coal face, a report is given to the supervisor by the operator at the bottom end of the coal face. Similarly, once the cause of a stoppage has been remedied, the news will soon be known throughout the coal face.

The electrician and mechanic can always be contacted quickly. They may receive communications and ask for information at any point.

- Special messages, instructions or orders can be transmitted very quickly by the management. Any necessary consultation can take place without difficulty and without material loss of time.

- Instructions to the operator at the bottom end of the coal face concerning the operation of the conveyor or plough can in practice be given from any point. Implementation of these instructions and the result can then be assessed and supplementary instructions given if necessary.

- Equipment can be requested from any point on the coal face.

- Instructions or messages concerning the transport of materials are rapidly known to all the persons concerned. Improved communication has a particular bearing on the speed and efficiency of the transport of materials by chain conveyor. The progress of operations can be followed at any point on the coal face and the necessary information transmitted.

- Progress at the coal face must be monitored constantly. Supervisors are in practice able to give the operator instructions from any point and can adjust the progress of work without loss of time, e.g. by double ploughing.

- In practice, it is important for information to be available quickly when a given situation is liable to result in an extended stoppage. Thanks to the improved communication, supervisory staff can intervene easily to adapt the organization at the coal face to the new situation. They may for example give instructions for certain work to be performed during a stoppage or for a rest break to be advanced or retarded. In this way the loss of time due to stoppages can be limited. However, it must be clearly noted that the loudspeaking telephone does not replace signals transmitted by means of the coal face lighting. These signals are still used because they represent a generally valid working method which cannot be modified at a single coal face, even in conjunction with staff changes. The procedure must be maintained for reasons of safety.

- The importance attributed by the management to the loudspeaking telephone as a safety factor must be stressed. The speed with which difficult situations become known and the rapidity of intervention in the event of an accident are significant factors.

Systematic observations

After the observations summarized above, further systematic observations were conducted to obtain more objective data.

This part of the study was conducted in the same way as the first study described in chapter I. Throughout a morning and afternoon shift, information received and transmitted by the loudspeaking telephone was systematically noted. For this purpose, the overman and operator at the bottom end of the coal face were observed minute by minute.

The data collected by the observers from minute to minute was then summarized in tables set out in annexes 9 and 11.

The figures in annexes 10 and 12 show how the overman moved around the coal face. They also indicate the times at which the overman and operator were involved in communication.

The data contained in annexes 9 and 11 shows that immediate answers are given to the questions raised. The causes of stoppages are soon known. It is apparent that supervisory staff can easily transmit instructions to electricians and mechanics without intervention by other persons. In general this systematic data confirms the information outlined above. It is also striking that a significantly higher number of messages and communications were received and transmitted.

It will be noted that the distance covered by the overman at the coal face did not change significantly during the trial period.

But it must also be remembered that a single overman was responsible for the whole coal face during this period and able to perform his work at the face without an increase in physical workload due to movements. The considerable variation in the distances covered by individual overmen are explained to some extent by differences in their personal working methods. These inter-individual differences are reflected in the figures contained in annexes 10 and 12.

For greater clarity, the distances covered in metres are also shown in table III-I below.

TABLE III-I: Record of distances covered by overmen at the coal face. The distance covered did not change significantly when the number of overmen was cut from two to one.

		Prior to introduction of the loudspeaking intercom	After introduction of the loudspeaking intercom
Morning shift	Overman I	678 m	468 m
	Overman II	488 m	
Afternoon shift	Overman I	978 m	810 m
	Overman II	768 m	

CHAPTER 4: THE EFFECT OF IMPROVED COMMUNICATION ON COAL FACE OUTPUT

When an ergonomics study is conducted, it is particularly important, after analysing the problem and the measures taken to remedy it, to try to determine the effect of these measures objectively.

In a laboratory situation, it is always relatively easy to obtain clear measurement data on the basis of which results can be assessed objectively. But when a study is carried out under normal operating conditions, nothing can be done which would interfere with operation of the plant.

It may even be said that the management will only accept an ergonomics study to the extent that it does not interfere with the work of the plant. The cost of an ergonomics study is accepted more readily than any risk to production.

In order to gain acceptance for ergonomics studies and an ergonomics approach in industrial undertakings and to integrate such studies into the everyday life of the enterprise, a working method must be found which will cut the risk of interference with the production process to a minimum. But it is then apparent that the task which we consider so essential, namely objective measurement of the effects of the ergonomics intervention, becomes difficult to carry out.

The objective effort to evaluate ergonomics measures during normal operation of the plant implies consideration of the data obtained with an appropriate sense of perspective. It will practically never be possible to obtain unambiguous data. In everyday life a number of imponderable factors always arise and their effects cannot be foreseen. Unknown factors are also encountered.

Without losing sight of these limitations, an attempt must be made to find objective data capable of giving the clearest possible indication of the effect of ergonomics measures taken as a result of prior analysis.

In our study of the effects of introduction of the loudspeaking telephone system, an attempt was made to compile objective data in two different ways:

1. first by interviews with management staff and personnel at the coal face;
2. secondly by collecting objective data on operations.

The programme of interviews

By the interview programme, an attempt was made to acquire the most impartial data possible on the positive or negative influence of the new means of communication on work at the coal face.

During the conversations, both supervisors and personnel expressed their appreciation of the new system. They viewed the loudspeaking intercom as a useful aid. However, very little differentiated data emerged from these interviews which the work study experts had hoped would provide a great deal of useful information. The attitude of the interviewees showed that they were not fully aware of the purpose of the questions asked them. They could not see what the questioners were driving at. They said that they viewed the new system as a valid aid which they could no longer do without. But they could not imagine what other information the questioners could possibly want. A solution had been found to a problem which had confronted them for many years and they simply wondered why this solution had not been arrived at sooner. They went so far as to assert that difficult situations which they had recently encountered could not have been overcome without this new aid.

But when the interviewees tried to question them further, they merely gave examples showing the convenience of the new

telephone. These were simple examples which sprang readily to mind and generally reflected the personal convenience of the new aid.

However, personal convenience is difficult to objectivize and this certainly cannot be done on the basis of such superficial data.

The personnel clearly felt that the new telephone made their task easier.

But it was impossible to determine objectively the impact of this personal convenience on the general progress of operations at the coal face. The interviews only revealed subjective comments of a positive nature which could scarcely provide evidence of an improvement in operations. Interviews are therefore not the most appropriate means of obtaining such proof.

During the interview programme, an attempt was made to determine the degree of audibility of the loudspeaking telephone system. Comprehensibility was found to present no difficulty at the coal face. However, it was substantially less good at the top and bottom ends of the face because of background noise, although it was still reasonable here according to the persons concerned. Since the loudspeaking telephone was used mainly during stoppages, there was no background noise at these moments.

The interviewees found that communications were often incomprehensible. Generally these were specific communications or messages using technical expressions. The interviewers solved this problem by asking persons working at the face what the message in fact said. A direct reply was given in almost all cases.

The messages were more comprehensible to personnel at the face because they were familiar with operations there and expected to receive certain communications.

Acquisition of data on operations

In addition to the compilation of factual data by an extensive interview programme, objective working data was also used to gain insight into the effect of improved communication on operations at the coal face.

In the case of all mechanized coal faces, operation of the plough is automatically recorded in the supervisors' room. All stoppages are noted on a special recording machine. They are brought to the attention of the supervisor in the control room. When a stoppage lasts for more than five minutes, he enquires into the reason for it. This data is recorded and was used in an attempt to define objectively the effects of improved communication.

The output from a coal face is largely dependent on the number and duration of stoppages. Since the reason for the latter is often unknown, improved communication can have little influence on the number of stoppages but it may be reasonably expected to reduce their duration. Similarly, improved communication may be expected to offer the possibility of adapting the organization of work more flexibly to different situations.

It may therefore be concluded that, all other circumstances being equal, the effect of improved communication will be reflected in a reduction in the total duration of stoppages and an increase in the percentage of plough time.

To collect data from coal face recordings, a period of two months was chosen prior to commissioning the telephone system (months I and II). This information was then compared with the results obtained in the two months following introduction of the new means of communication (months IV and V).

The month in which the loudspeaking telephone system was brought into service (month III) was disregarded. After month V the geological conditions at the coal face changed considerably due to wash-out operations throughout the face.

Figure IV - I is a map of the coal face. The working positions on different dates are shown on this chart which also clearly indicates that months VI to X were not comparable with the preceding and following months.

Table IV-2 summarizes the number of minutes of stoppages per shift and the percentage of plough time at the face. There was a distinct increase in plough time in the period IV - V by comparison with I - II. The number of minutes of stoppages per shift in period IV - V was also substantially less than in period I - II. In period XI, i.e. after a number of months during which the geological conditions were particularly difficult, this favourable result was no longer achieved. It should, however, be noted that working conditions had then changed considerably from those in months I - V.

Table IV-2: Summary of minutes of stoppages per shift and percentage of plough time at panel U^2 and at all coal faces in the pit.

Months	I/II	IV/V	XI
Number of shifts	71	81	40
Minutes stoppage	11318	10365	6143
Minutes stoppage per shift	160	128	153
Percentage plough time, U^2	44.6	56.2	45.7
Percentage plough time, all coal faces	46.8	50.3	46.4

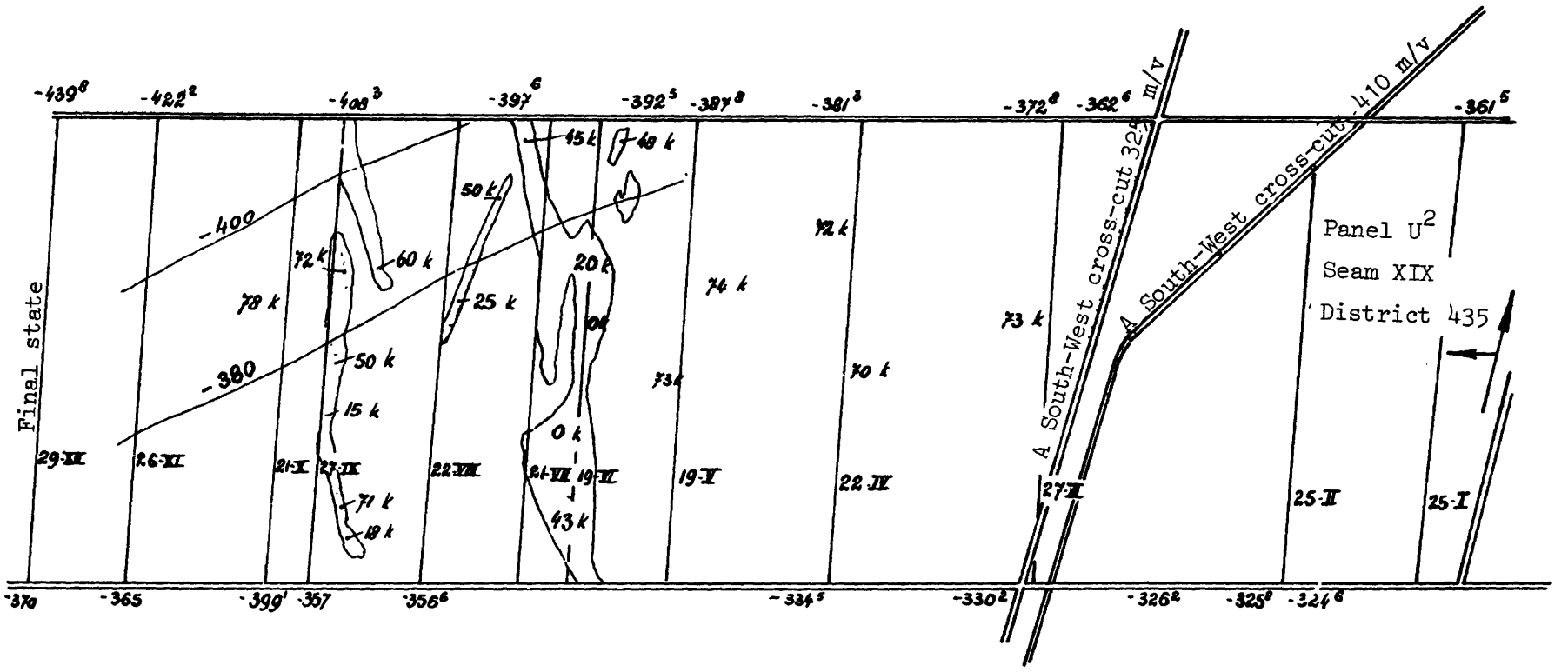


Figure IV-I: Map of coal face. Indication of coal face positions on different dates. The reduction in thickness of the seam in months VI - X due to peat wash-out is evident.

For practical reasons, a more or less arbitrary distinction was made between stoppages lasting less or more than five minutes.

Stoppages lasting more than five minutes were recorded individually. The number and explanation of the stoppages are therefore known.

In the case of stoppages lasting less than five minutes only the total duration is known.

Table IV-3 summarizes the duration of stoppages, a distinction being made between those lasting more (> 5') or less (< 5') than five minutes. The data in table IV-3 clearly shows a reduction in the number of stoppages lasting more than five minutes in the period IV-V. This effect disappeared again in period XI. There is, however, considerable doubt as to whether this period immediately prior to the probable end of working of the coal face can be compared with period IV-V.

Table IV-3: Summary of duration of stoppages exceeding (>5') or less than (< 5') five minutes.

Months		I/II	IV/V	XI
> 5'	Number of shifts	71	81	40
	Number of stoppages	471	515	225
	Total stoppages in minutes	8441	6771	4212
	Minutes of stoppage per shift	119	84	105
	Minutes of stoppage in each instance	18	13	19
< 5'	Total stoppages in minutes	2877	3594	1931
	Minutes of stoppage per shift	41	44	48

It would be interesting to determine the extent to which there has been any change in the causes of stoppages. These causes may be centred on the coal face or elsewhere. It is only possible to analyse data relating to stoppages lasting more than 5 minutes. Table IV-4 summarizes stoppages of more than 5 minutes depending on whether the cause is situated at the coal face or elsewhere; it indicates a clear reduction in the duration of stoppages due to incidents at the coal face in period IV-V.

It is also significant that the duration of stoppages due to external causes either remains unchanged or does not alter in the same way. Here again, the effect disappears in the 11th month.

The increase in the duration of stoppages due to external causes suggests that conditions in the panel as a whole were more difficult than in the period from the 1st to 5th months.

Months	I/II	IV/V	XI
Number of shifts	71	81	40
Cause at coal face			
- Number of stoppages	363	394	176
- Total stoppage in minutes	6891	5015	3330
- Individual stoppage in minutes	19	13	19
- Minutes of stoppage per shift	97	62	83
Causes external to coal face			
- Number of stoppages	108	121	49
- Total stoppage in minutes	1550	1756	882
- Individual stoppage in minutes	14	15	18
- Minutes of stoppage per shift	22	22	22

Table IV-4: Summary of stoppages lasting more than 5 minutes with distinction between causes of stoppage at coal face and elsewhere.

A more detailed analysis can be made of the causes of stoppages. There may be many such causes at the coal face. Observations clearly showed that better communication enabled time to be saved. The duration of stoppages occurring after alarm signals could be limited. The transport of materials and the safety measures and positioning of props at the coal face were better coordinated. Thanks to efficient and rapid communication, it was possible to organize the transport of materials at more appropriate times.

Stoppages affecting small sectors only were therefore avoided.

The same applies to safety measures and positioning of props at the coal face; this work could be carried out when there was a likelihood of a stoppage occurring or lasting some time.

It may also be assumed that by making for smoother operations, better communication reduces the frequency of difficulties which make it necessary to stop work at the coal face.

In fact, better communication enables the foreseeable interruptions in work to be adapted to fit in more harmoniously with the general organization of work.

Difficult situations can be remedied at times when work at the coal face stops for other reasons. Thanks to better communication working time can be organized more effectively.

The three above reasons, i.e. transport of materials, organization of safety and fitting of props at the coal face as well as emergency shut-downs are in fact the most frequent causes of stoppages.

Tables IV-5, IV-6 and IV-7 summarize the duration and number of stoppages attributable to the transport of materials, organization of safety and positioning of props at the coal face, alarm signals from the coal face or actuation of the emergency switches.

Table IV-5 shows a substantial reduction in the duration and number of stoppages resulting from the transport of materials.

Table IV-5: Summary of number and duration of stoppages due to the transport of materials.

Stoppages due to the transport of materials (>5')			
Months	I/II	IV/V	XI
Number of shifts	71	81	40
Number of stoppages	81	28	7
Number of minutes	1534	325	76
Number of minutes per stoppage	19	12	11
Number of minutes per shift	22	4	2

Similarly, the number and duration of stoppages due to the organization of safety measures and the positioning of props at the coal face are shown in table IV-6.

Table IV-6: Summary of number and duration of stoppages due to safety measures and positioning of pit props at the coal face.

Stoppages due to safety measures and positioning of props at the coal face (>5')			
Months	I/II	IV/V	XI
Number of shifts	71	81	40
Number of stoppages	59	4	6
Number of minutes	1715	85	148
Number of minutes per stoppage	29	21	25
Number of minutes per shift	24	1	4

Table IV-7 shows a substantial reduction in the number of stoppages per shift. However there was, understandably enough, no reduction in the total duration of stoppages. It may be assumed that improved communication enables emergencies to be avoided but that when such difficulties arise, the time needed to eliminate them is probably no shorter.

Table IV-7: Summary of number and duration of stoppages due to alarm signals from the coal face or actuation of an emergency switch.

Stoppages due to alarm signals or actuation of an emergency switch			
Months	I/II	IV/V	XI
Number of shifts	71	81	40
Number of stoppages	52	16	5
Number of minutes	478	163	47
Number of minutes per stoppage	9	10	10
Number of minutes per shift	7	2	1

Figures IV-8, IV-9 and IV-10 show the above-mentioned causes of stoppages, recorded over a large number of periods, in graphic form. The figures only indicate the average number of stoppages per shift due to the three above causes. The totals obtained in this way are compared with the average number of stoppages per shift recorded for all the mechanized coal faces in the pit.

Figures IV-8 to IV-10 indicate a substantial improvement in the results at the coal face in the months following introduction of the new telephone system. The positive effect may be attributed in large measure to the fact that the first month of observation corresponded to the period in which the coal face was brought into production.

Even without an improvement in communication, better results would normally have been expected in the second month. However, this did not prove to be the case on the whole. The number of stoppages caused by alarm signals was higher in the second month than in the first.

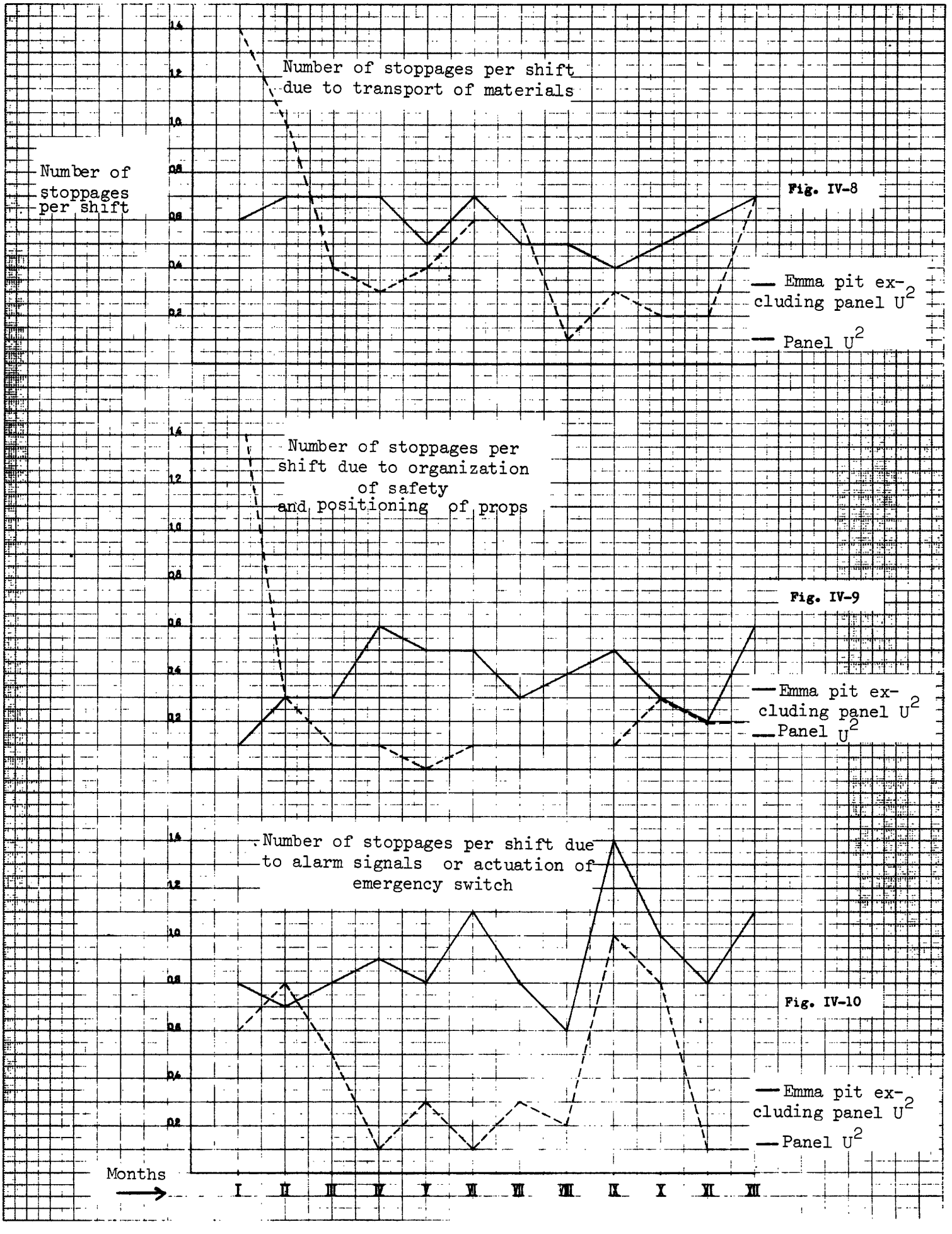
The work study experts had not made sufficient allowance beforehand for the problems arising in the month of start-up. Had they done so, the equipment would perhaps have been installed one month later. However, under these conditions, only one month's observation would have been possible after bringing the installation into service. During the 6th month, the geological wash-out would in any case have been encountered, rendering any comparison of the results impossible.

The graphs in figure IV-10 show a surprising trend. In the 9th and 10th months the number of stoppages due to alarm signals is found to increase. It is surprising that the same phenomenon should occur at all the coal faces. Coal face U^2 follows this general trend. A more detailed analysis of the daily reports revealed the following information.

A serious accident occurred during the 8th month. A worker who had carelessly tried to remove equipment from the conveyor was seriously injured in the hand. This accident was followed

by a safety campaign which very probably caused an increase in the number of alarm signals during the next two months. As the figure shows, this effect had disappeared after two months.

In conclusion, it may be stated that stoppages at coal face U^2 stand favourable comparison with those in the pit as a whole despite the fact that it was considered a difficult face by the management. These very difficulties had encouraged the management to organize the experiment in improved communication at this particular coal face.


Number of stoppages per shift due to transport of materials
Number of stoppages per shift
Fig. IV-8
Emma pit excluding panel U2
Panel U2
Number of stoppages per shift due to organization of safety and positioning of props
Fig. IV-9
Emma pit excluding panel U2
Panel U2
Number of stoppages per shift due to alarm signals or actuation of emergency switch
Fig. IV-10
Emma pit excluding panel U2
Panel U2
Months
I II III IV V VI VII VIII IX X XI XII

Summary

The purpose of this project was to improve communication at the coal face by installing a loudspeaking telephone system.

Objective data suggested that the measures were successful. However, this data must be considered in perspective. The positive effect cannot be attributed unambiguously to any particular measure. In a field study such as this, the real conditions are too complex. Physical factors are only perceived and predictable to a very limited extent in a coal mine.

A coal mine is a complicated organic and dynamic system. The coordination patterns are complex.

To ensure harmonious work coordination, many physical obstacles to communication must be overcome. In other words, a field study in a coal mine bears little resemblance to a laboratory experiment.

Nevertheless, an attempt was made to obtain practical proof by essentially experimental means.

Convinced of the value of the loudspeaking telephone, the management decided to equip two coal faces with installations of this kind in the 12th and 13th months. For the work study experts this was an ideal opportunity to posit specific assumptions as to the effects of this new aid. These assumptions could then be tested.

The results obtained in the two new coal faces were much less clear but a similar effect was noted to that observed at coal face U^2 in regard to the number of stoppages caused by alarm signals and actuation of the safety switch. Subsequently, during graphic representation of data for coal face U^2, the involuntary secondary effect of the safety campaign organized

in months IX and X was observed. This undesirable secondary effect - which is also unnecessary if work is organized correctly - of the safety campaign diminished considerably in subsequent months. This was observed throughout the coal mine. The favourable result, i.e. the reduction in stoppages at the two new coal faces equipped with telephones was certainly attributable in part to this circumstance. As a result the overall impression was altered and cannot be held to provide sufficient proof.

The subjective impressions of the supervisory staff and personnel at the coal face confirm the favourable impression of the objective data. As stated earlier, the interviews in which this subjective data was collected presented certain problems. Whenever the impressions of workers at the coal face were obtained, they simply stressed their personal convenience which was difficult to express in objective terms.

It is perhaps still more difficult to estimate the impact of the system on output.

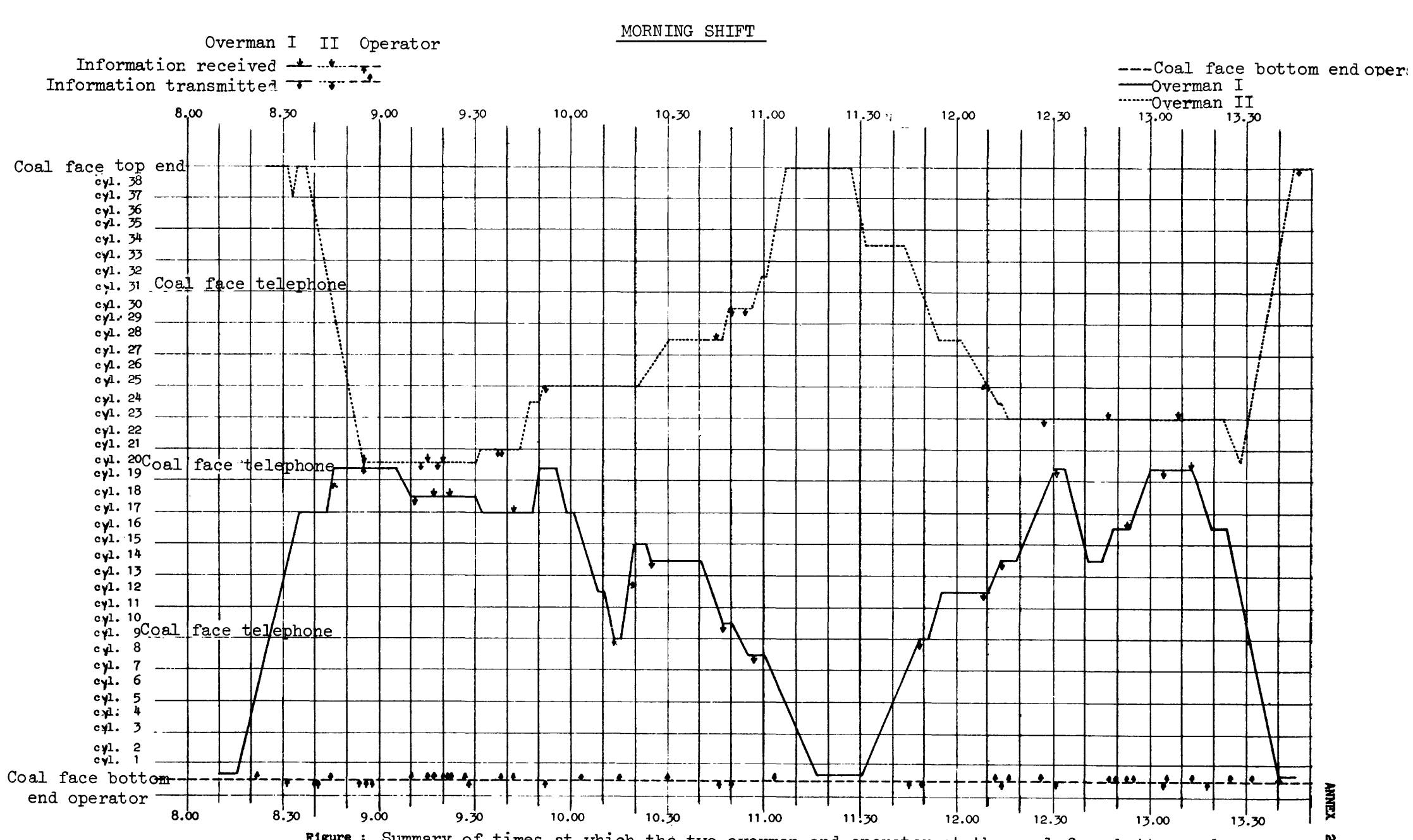
However, it must not be forgotten that a person who is exposed to particular inconvenience may grow accustomed to it and adapt himself accordingly. But this is only possible up to a certain point and the limit varies from individual to individual. Beyond this point, little adaptation is possible. When a lift breaks down in an apartment block, the occupants make do and use the staircase. But a physically handicapped person may be obliged to stay in his apartment. Each individual has moved closer to the point beyond which no further adaptation is possible. The handicapped person is the only one who has passed beyond this threshold and clearly sees the effect of the new situation. It is impossible to determine the extent to which the introduction of an easier means of communication widens the margin of adaptation for all personnel at the coal face. There is, however, good reason to suppose that the margin is widened. And it is this factor which personnel are expressing when they say that they experienced additional personal convenience.

Summary of informational contacts between the two overmen and operator at the bottom end of the coal face (prior to installation of the loudspeaking telephone) - Morning shift.

Time	Person speaking			Message from or for	Content
	Operator	Overman	Other		
8.22	x			Coal face top end	Tel: can we start ?
31			x	Operator	Tel: why have we stopped ?
40			Coal face top end	Operator	Tel: why have we stopped ?
41			Coal face top end	Operator	Tel: why have we stopped ?
45			x		Call: large block jammed on cylinder 2
45	x			Overman I	Tel: large block jammed on cylinder 2
50	x			Coal face top end	Tel: automatic plough control defective
54			x	Operator	Shout: go ahead.
55		I + II			Discussion of work
56			Coal face top end	Operator	Tel: send plough up
58			Electri-cian	Operator	Tel: is the automatic plough control working ?
9.10	x			Coal face top end	Tel: turn emergency switch on
11		I			Shout: why have we stopped ?
13		II		Coal face bottom end	Tel: why have we stopped ?
15	x			Overman II	Tel: stop from loading hopper
17	x			Overman I	Tel: stop from loading hopper
18		II			Shout: send down air hose
20	x			Loader	Tel: why have we stopped ?
20	x			Overman II	Tel: tub pusher still pushing
21	x			Coal face top end	Tel: is the mechanic up there ?
22	x			Overman I	Tel: tub pusher still pushing
27	x			Coal face top end	Tel: call for materials
28			Loader	Operator	Tel: sensor not working properly
37		II			Shout: where did signal 5 + 1 come from ?

Time	Person speaking: Operator	Overman	Other	Message from or for	Content
38	x			Cylinder 20	Tel: no empty tubs
38		II			Shout: no empty tubs
42	x			Overman I	Tel: no empty tubs
51		II			Shout: telephone cylinder 20 to find out reasons for stoppage
52			x	Operator	Tel: why have we stopped ?
10.03	x			Coal face top end	Tel: why have we stopped ?
04			x	Operator	Tel: why have we stopped ?
13		I			Conversation with plough operator
15	x			Coal face top end	Tel: send props down
18		I			Shout: telephone cylinder 20 to find out reasons for stoppage
25		I			Conversation with plough operator
30	x			Coal face top end	Tel: where are the props ?
45			x	Overman II	Shout: large block jammed on cylinder 31
46			Supervisor	Operator	Tel: why have we stopped ?
47		I			Shout: why have we stopped ?
50		II		Operator	Tel: why have we stopped ?
54		II			Shout:how long will the large block remain jammed on cyl. 31 ?
57		I			Shout: where did signal 5+1 come from ?
11.03	x				Shout: where did signal 5+1 come from ?
18	x			Coal face top end	Tel: by how much should we depart from specified direction ?
45			Coal face top end	Operator	Tel: where is the mechanic ?
48		I			Conversation with respons. official
49			Coal face top end	Operator	Tel: as soon as plough arrives, start double ploughing
12.08		I			Shout: why have we stopped ?
09		II			Shout: why have we stopped ?
13				Coal face top end	Tel: turn emergency switch on
14			Coal face top end	Operator	Tel: emergency switch on
14		I			Shout: why have we stopped ?

Time	Person speaking: Operator	Person speaking: Overman	Person speaking: Other	Message from or for	Content
16	x			Coal face top end	Tel: send props down for cyl. 2
26	x				Tel: firing at coal face bott.end
27		II			Shout: firing at coal face bottom end
31		I		Operator	Tel: large block jammed on cyl.17
47	x				Tel:large block jammed at coal face bottom end
47			x	Overman II	Shout: large block jammed at coal face bottom end
49	x			Coal face top end	Tel: turn emergency switch on
53	x			Overman I	Tel: large block jammed at coal face bottom end
55	x			Coal face top end	Tel: turn emergency switch on
13.04		I		Operator	Tel: why have we stopped ?
05	x			Coal face top end	Tel: 4th loader belt has broken down
08			x	Overman II	Shout: 4th loader belt stopped
13	x			Overman I	Tel: stoppage at 4th loader belt
18			Coal face top end	Operator	Tel: inform mechanic that he must stay for overtime
25	x			Coal face top end	Tel: supervisor requires information on situation at coal face
30			Coal face top end	Operator	Tel: do not depart from specified direction by more than 2.20 m
32	x			Coal face top end	Tel: turn on emergency switch on
40		I			Notify coal face position to supervisor
46		II			Notify coal face position to supervisor



ANNEX 2

Figure : Summary of times at which the two overmen and operator at the coal face bottom end were involved in communication over a distance (↗). The time is shown on the x-axis and points on the coal face (scraper cylinder numbers) on the y-axis. Situation prior to installation of loudspeaking telephone.

ANNEX 3

Summary of informational contacts between the two overmen and the operator at the coal face bottom end (prior to installation of the loudspeaking telephone)- Afternoon shift.

Time	Person speaking			Message from or for	Content
	Operator	Overman	Other		
16.05	x			Supply	Tel: where is mechanic ?
07	x			Coal face top end	Tel: where is mechanic ?
08		II		Operator	Tel: are there any spare men ?
09	x			Loader	Tel: where is mechanic ?
16	x			Supervisor	Shout: where is mechanic ?
18			Coal face top end	Operator	Tel: are there any spare men ?
19		I		Operator	Tel: why is there no low pressure?
20			Coal face top end	Operator	Tel: ploughing without low pressure ?
20		I			Shout: send hammer down
21			x	Operator	Tel: why is there no low pressure?
23		II		Operator	Tel: why is there no low pressure?
25	x			Coal face top end	Tel: send props down
26			Control room	Operator	Tel: why have we stopped ?
27			x	Operator	Tel: why is there still no low pressure ?
30			Control room	Operator	Tel: why have we stopped ?
30		I + II			Conversation concerning despatch of props
31	x			Supervisor	Tel: is the mechanic coming ?
31		I		Coal face top end	Tel: is the mechanic coming ?
32		II		Coal face top end	Tel: is the mechanic up there ?
36			Loader	Operator	Tel: is the coal face already working ?
37			x	Operator	Tel: plough will not go up
38	x			Loader	Tel: is the mechanic there ?
40			Supervisor	Operator	Tel: why have we stopped ? Answer: plough stuck
48			Control room	Operator	Tel: why have we stopped ? Answer: no low pressure

Time	Person speaking: Operator	Person speaking: Overman	Person speaking: Other	Message from or for	Content
53			Coal face top end	Operator	Tel: as soon as materials reach the coal face top end, start the conveyor
55			Coal face top end	Operator	Tel: the props are arriving
59		II			Shout: props arriving
17.01			Control room	Operator	Tel: what is the matter with Pleiger pump ?
03	x			Coal face top end	Tel: automatic plough control defective
03		II			Shout:pit props coming
04		I			Shout: pressure at cylinders
08		II		Operator	Tel: why is the plough not working automatically ?
10		II		Operator	Tel: concerning plough operation
12	x			Coal face top end	Tel: turn emergency switch on
13		I			Conversation with plough operator
18		I			Conversation with hewer
24		I			Conversation with hewer
26	x			Coal face top end	Tel: have the materials left ?
28	x				Tel: no low pressure
28		I			Shout: telephone cyl. 20 to find out why there is no low pressure
		II			Shout: why have we stopped ?
30	x			Coal face top end	Tel: there is no low pressure
		II			Shout: no low pressure
31			x	Operator	Tel: why is there no low pressure?
32		II		Operator	Tel: do not plough when there is no low pressure
32		I		Operator	Tel: is the mechanic working on Pleiger pump ?
33		II		Operator	Tel: what is wrong with the Pleiger pump ?
33		I			Shout: send shovel down
34	x			Control room	Tel: no low pressure
38		II			Shout: where has the 5+1 signal come from ?
42	x			Coal face top end	Tel: why 5 + 1 ?
44			Coal face top end	Operator	Tel: is there still no low pressure ?

Time	Person speaking: Operator	Overman	Other	Message from or for	Content
44		II			Shout: no ploughing without low pressure
.46		I		Operator	Tel: for how long will there be no low pressure ?
47			Control room	Operator	Tel: why is there no low pressure?
48			Coal face top end	Operator	Tel: why have we stopped ?
48		I		Operator	Tel: for how long will there be no low pressure ?
49		I			Shout: put cylinders under pressure
53		I			Shout: why was 5+1 signal sent ?
55			Coal face top end	Operator	Tel: what was wrong with Pleiger pump ?
55		I			Shout:send plough down
56		I			Shout: where was 5+1 signal sent?
58			x	Operator	Shout: large block jammed on cyl. 7
58		I			Shout: send plough down
59		II		Operator	Tel: why have we stopped ?
59		II			Shout: send saw up
18.00	x			Loader	Tel: why have we stopped ?
00		I		Operator	Tel: why have we stopped ?
01			Coal face top end	Operator	Tel: why have we stopped ?
02		I		Operator	Tel: coal face lighting broken; send for electrician
02		II			Shout: why have we stopped ?
03	x			Cylinder 9	Tel: can we start ?
04			x		Shout:large block jammed on cyl.7
05			Control room	Operator	Tel: why have we stopped ?
05	x			Overman II	Tel: large block jammed at coal face bottom end
06			Coal face top end	Operator	Tel: is there low pressure now ?
07		I			Shout:why has light gone out ?
08			Coal face top end	Operator	Tel: why have we stopped ? Answer: emergency switch actuated
12	x			Coal face top end	Tel: where did the signal 5 + 1 come from ?
13	x				Shout: where did the signal 5 + 1 come from ?

Time	Person speaking			Message from or for	Content
	Operator	Overman	Other		
13		I		Operator	Tel: why have we stopped ?
14			x	Operator	Shout: start
15			Coal face top end	Operator	Tel: why have we stopped ? Answer: large block jammed at coal face bottom end
15		II			Shout: call cyl. 20 to find out reason for stoppage
25		I		Operator	Tel: do not double plough
27	x			Coal face top end	Tel: why 5 + 1 ?
30			x	Overman II	Shout:large block jammed on cyl.30
34			x	Overman II	Shout:large block jammed on cyl.29
38	x			Overman II	Tel: firing at coal face bottom end
40		I			Shout: shorten scraper cylinders
45	x			Loader	Tel: why have we stopped ? Answer: large block jammed in hopper
47			3°-4°AB	Operator	Tel: why have we stopped ?
48		I		Operator	Tel: why have we stopped ?
54		II			Shout: call cyl.20 to find out reason for stoppage
56		I		Coal face top end	Tel: information on direction
56			x	Overman II	Shout: stoppage at loading hopper
59			x	Operator	Tel: how far have we departed from and why have we stopped ?
19.10		I		Coal face top end	Tel: information on direction
14			x	Operator	Tel: why have we stopped ?
17	x			Overman II	Tel: cap loose at coal face bottom end
22			x	Operator	Tel: why have we stopped ?
25		I			Shout: shorten scraper cylinders
28		I			Shout: shorten scraper cylinders
30		II		Operator	Tel: what is the direction ?
43			x	Operator	Tel: why have we stopped ?
44			Coal face top end	Operator	Tel: why have we stopped ?
48		I + II			Conversation concern. direction
48		I		Operator	Tel: coal face bottom end must depart from direction by 4.80 m

Time	Person speaking: Operator	Overman	Other	Message from or for	Content
50		I		Operator	Tel: double plough
51		I		Operator	Tel: call coal face top end by panel telephone for information on direction
52			x	Overman I	Shout: go to supervisor
53	x			Coal face top end	Tel: coal face top end must depart from direction by 4.80 m
20.00		II			Shout: why have we stopped ?
01		II			Shout: where signal 5+1 come from?
06			Supervisor	Overman I	Shout: help overman at cyl. 7
08		II			Shout: add cylinders
15	x			Coal face top end	Tel: turn emergency switch on
18			Coal face top end	Operator	Tel: why have we stopped ?
20			Control room	Operator	Tel: why have we stopped ?
39		II			Shout: notify cyl. 31 that a large block is jammed at cyl. 33
40			Coal face top end	Operator	Tel: why have we stopped ?
41			Control room	Operator	Tel: why have we stopped ?
43		II			Shout: call cyl.31 to find out reason for stoppage
45			Loader	Operator	Tel: why have we stopped ?
46			Coal face top end	Operator	Tel: why have we stopped ?
21.00			Control room	Operator	Tel: why have we stopped ?
05		I			Shout: why have we stopped ?
12	x			Coal face top end	Tel: turn emergency switch on
13		II			Shout: why have we stopped ?
18		I		Operator	Tel: lower plough to cyl. 15
18		II			Shout:why was signal 5+1 given?
23		I + II			Conversation concern.double ploughing.
30			Superv.	Operator	Tel: is coal face bottom end in correct direction ?
35			Superv.	Operator	Tel:what is output at coal f.bott.e
44		II		Supervisor	Tel: informa.on c.face position

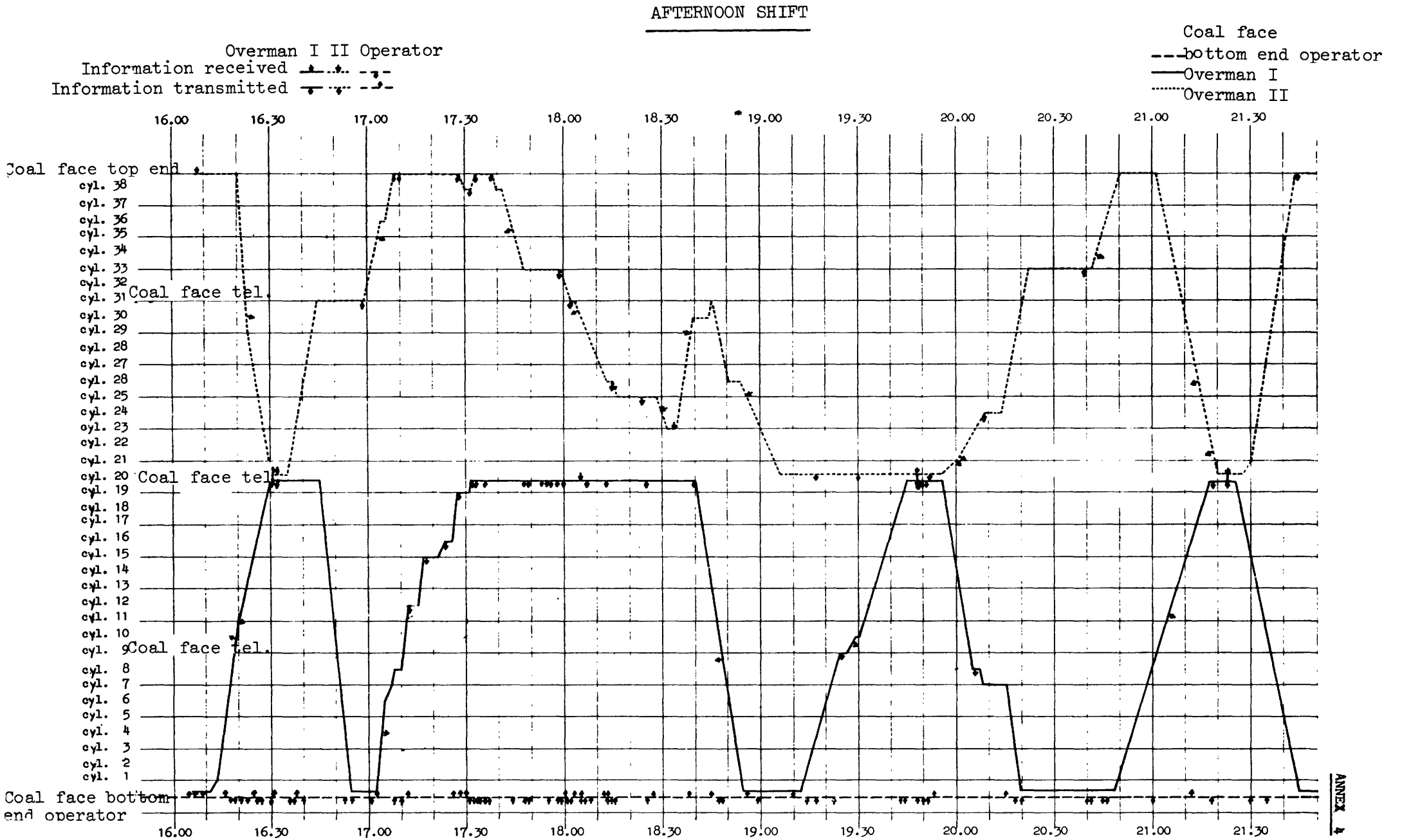
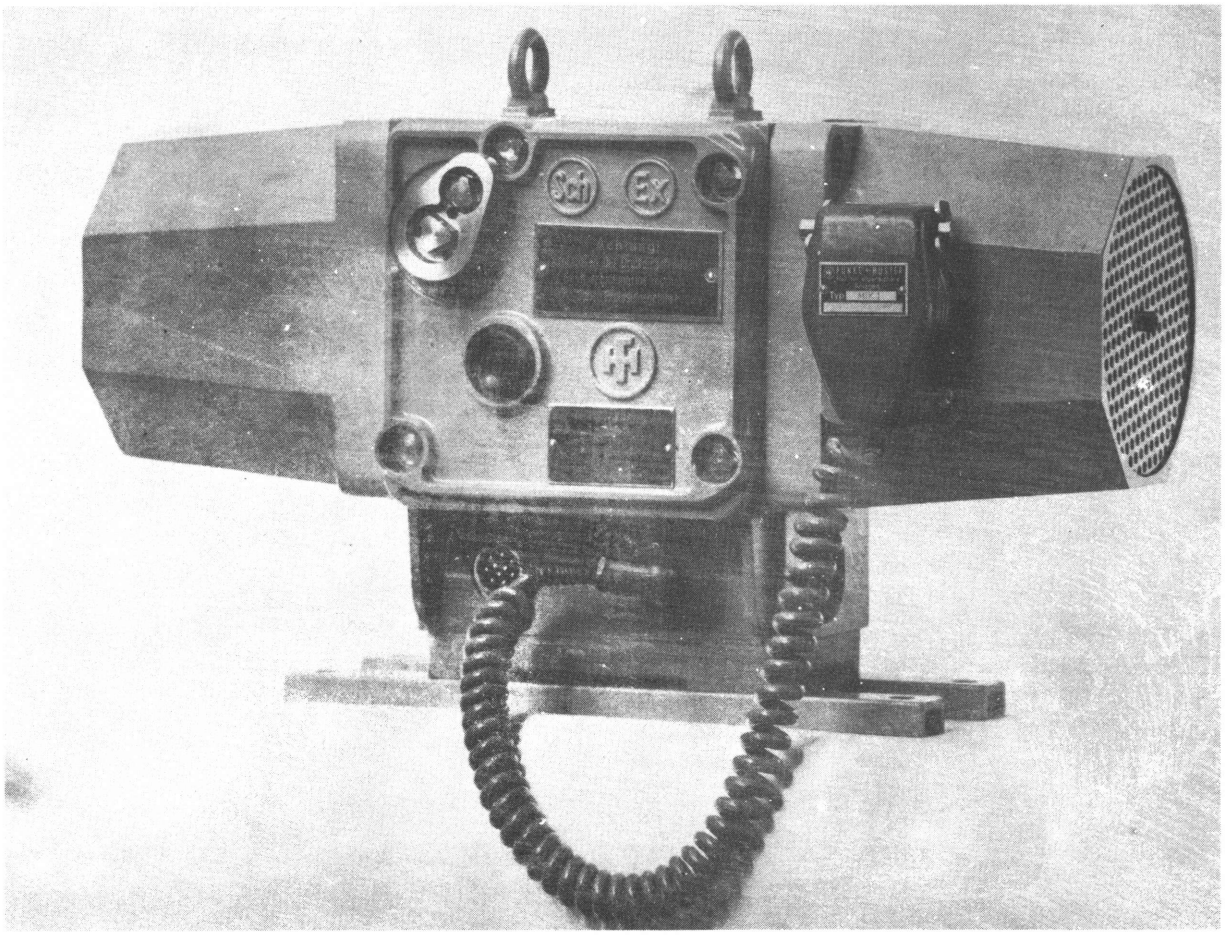
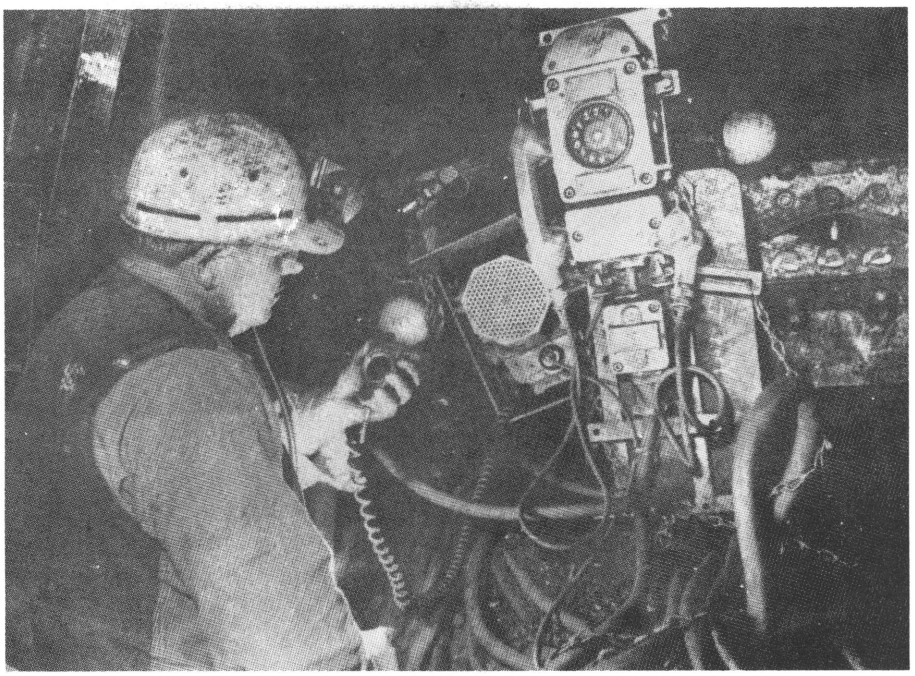


Figure : Summary of times at which the two overmen and operator at the coal face bottom end were involved in communication over a distance (↗). The time is shown on the x-axis and coal face points (scraper cylinder numbers) on the y-axis. Situation before installation of loudspeaking telephone.

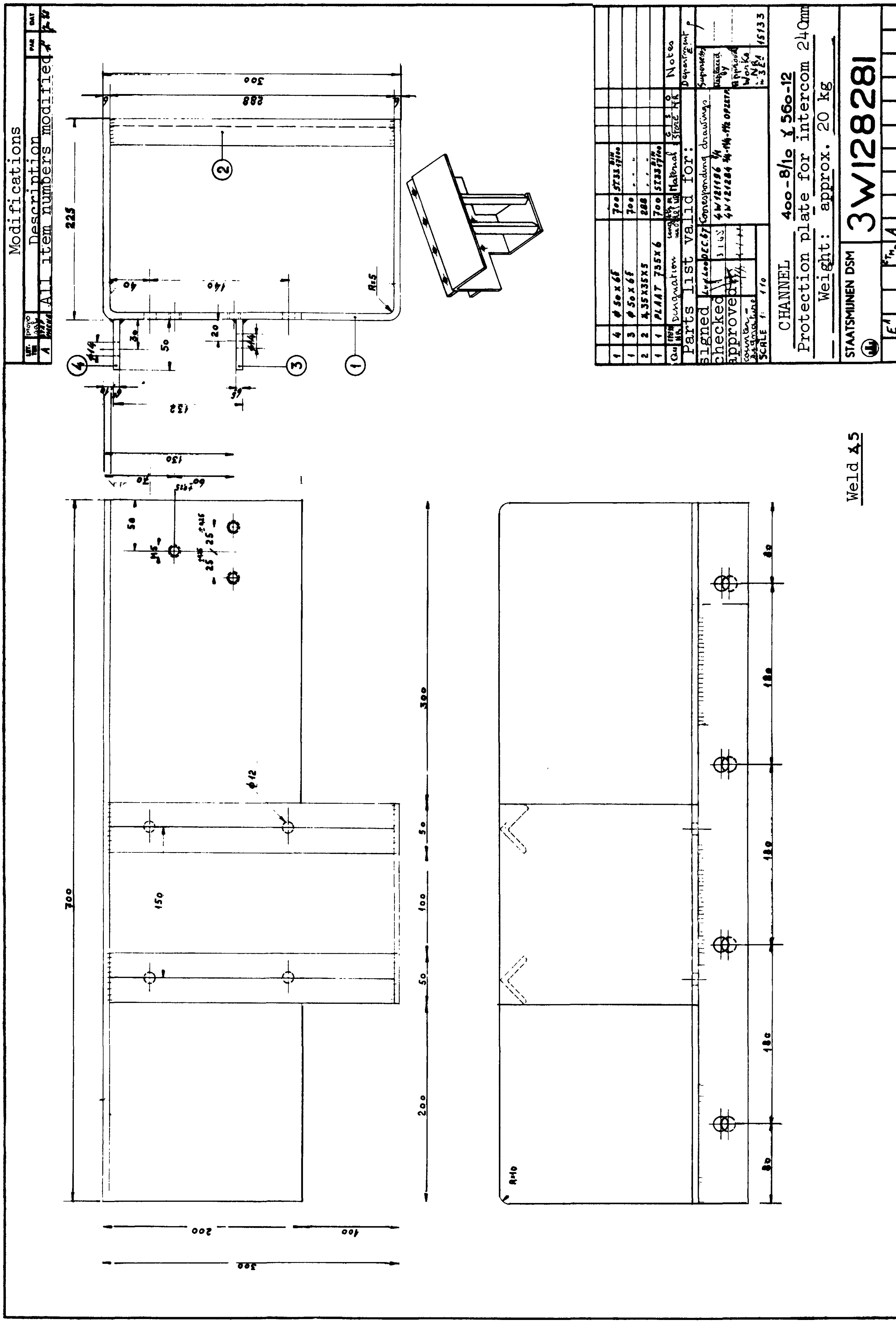


Loudspeaker/microphone set; intercom system W.L. 20

Overman speaking to personnel at coal face



Operator at coal face bottom end speaking
to coal face personnel


Modifications
Description
All item numbers modified
Parts list valid for:
signed
checked
approved
Notes
CHANNEL 400-8/10 X 560-12
Protection plate for intercom 240mm
Weight: approx. 20 kg
STAATSMIJNEN DSM
3W128281
Weld 5

ANNEX 9

Summary of informational contacts between overman and operator at the coal face bottom end (after installation of loudspeaking telephone) - Morning shift.

Time	Person speaking: Operator	Overman	Other	Message from or for	Content
8.12			x		Send shovel down
13			x	Operator	Advance conveyor by a few metres for preparatory work at coal face top end.
13			x		Send hammer for cylinder 10
14			Superv. Frissen	Overman	What is position at conveyor ?
		x		Supervisor	Cylinders 6 and 7 are late
15			Superv.		The Moroccan must go to cyl. 19
15			Superv.	Operator	Advance coal face conveyor by a few metres
18			x		Send hammer for cylinder 13
23			x		Large blocks jammed on cyl.13-14
25		x			Where did signal 5+1 come from?
25	x			Overman	Large blocks jammed on cyl. 13
29	x				Large blocks jammed at coal face bottom end
33			x		Who needs shovel ?
33			Superv.	Overman	Come to radio station
		x		Supervisor	Information on coal face position
34			Superv.	Overman	Tell men to drive keys well into props
36			Superv.I	Operator	Start but do not plough
37		x		Operator	Why have we stopped ?
39		x		Operator	Double ploughing at cylinder 8
41			Superv.I	Overman	Send Moroccan to cylinder 20
42			x	Overman	Send shovel for cylinder 38
42			x	Overman	There are still spare men; where must they go ?
43		x		Operator	Double ploughing from cyl. 4 to cylinder 9
44			Chief	Operator	Send remaining men to cyl.19-20
45			Superv.	Overman	Send Moroccan off coal face if he does not go to cylinder 20
45			x	Overman	Send shovel
45			Superv.I	Overman	The Moroccan must go to cylinder 20 as agreed
46		x		Supervisor I	The Moroccan refuses to go to cylinder 20

Time	Person speaking: Operator	Person speaking: Overman	Person speaking: Other	Message from or for	Content
47			x	Operator	Radio defective at cyl. 20
49	x				No shovels left at coal face bottom end
54		x		Operator	No more double ploughing
55		x		Operator	Why have we stopped ?
	x			Overman	Discharge belt has stopped
57		x			Who does not have a shovel yet?
58		x		Operator	Why have we stopped ?
	x			Overman	Stoppage at loading hopper
9.01		x			Warning,there is a shovel on conveyor
03			x	Operator	Why have we stopped ?
	x				The first belt has broken down
05		x		Operator	Deviation of 1.50m from axis
05		x		Coal face top end	Deviation of 1.50m from axis
07		x		Operator	Why has first belt stopped ?
08		x			There is a shovel on conveyor above cylinder 28
13	x				The first belt is out of action; panel supervisor is on his way
18			x	Operator	Why is plough not coming down ?
23			x	Coal face top end	Send 10 base blocks down
23	x			Coal face top end	Send 20 more sleepers down
24			x	Operator	Pull the plough away
25		x		Chief overman	Go to cylinder 20
28	x				Has loader belt stopped ?
29			x	Chief overman	Someone must go up; conveyor is under coal at cylinder 28
31	x				Loader conveyor stopped
33			Superv.	Overman	Double ploughing at cylinder 14
33			x	Operator	Why is there still a stoppage at loader belt ?
35	x				Loader belt stopped
35			Superv.	Coal face top end	Send wooden props down for cyl.14
37			x	Operator	The plough must rise
40			x	Coal face top end	Send 10 sleepers down for cylinders 35 and 38

Time	Person speaking: Operator	Person speaking: Overman	Person speaking: Other	Message from or for	Content
51	x				Discharge belt stopped
57		x		Coal face top end	What is deviation of coal face top end from correct direction?
57		x		Chief overman	What is your deviation from correct direction ?
58		x		Chief overman	What is your deviation from correct direction ?
10.00		x		Operator	What is deviation from correct direction at coal face bott.end?
02	x				Large block jammed at coal face bottom end
03			x	Supervisor	Supervisor must go down; man at cylinder 6 has had an accident
09			x	Operator	Why have we stopped ?
	x				Hewer crossing coal face bottom end with explosives
12		x		Operator	How many men are down there from 9.00 h ?
13		x		Official	Information on direction
17			Superv.	Official	Information on accident
18	x				Emergency switch actuated at coal face
20		x		Operator	Why have we stopped ?
	x			Overman	Change sensor at loading hopper
		x		Operator	If it requires a long time, take a meal break
21			x	Operator	Sensor has been changed, stop the break
28			x	Operator	Why have we stopped ?
33			x	Operator	Raise the plough
34		x		Operator	Operate plough by radio
41			x	Operator	Why have we stopped ?
	x				Loader belt stopped
			x	Operator	Send chief overman to find out why
43		x			Request information on direction and accident
44		x		Chief overman	What is your deviation from correct direction ?
44		x		Chief overman	What is your deviation from correct direction ?

Time	Person speaking			Message from or for	Content
	Operator	Overman	Other		
55			x	Operator	What is pressure gauge reading ?
55			x	Operator	1x double ploughing from cylinder 7 to cylinder 14
57			x	Operator	Why have we stopped ?
	x				Loader belt stopped
			x	Operator	Take a break
11.01			x	Chief overman	Go to cylinder 14 with Bahco spanner
03			Superv.	Supervisor I	Double ploughing from cyl.4 to 14
09			x	Operator	Is loader working ?
	x				Yes
			x	Operator	Start with double ploughing from cylinder 4 to cyl. 14
11			x	Operator	Lower plough
19	x				Send electrician to loading hopper; the tub pusher is stopping.
19	x				Mechanic must go to cyl. 14
27	x				What is the matter at coal face?
			x	Operator	Large block jammed at cyl. 5
28			x	Operator	Start, do not plough. Where was signal 5 + 1 emitted ?
			x	Operator	Large block jammed at cyl. 5
30		x		Chief overman	Go to cyl.22,correct cyl.position
32	x				Where did 5+1 signal come from ?
32	x				Why have lights gone out ?
32	x				Check push-buttons
36		x		Operator	What is deviation at coal face bottom end from true direction?
36			x	Coal face top end	Release blocks as soon as plough has been raised
37		x		Chief overmen	What is your deviation from true direction ?
38			Coal face top end	Operator	Blocks are coming down
41			x	Operator	Warning,large blocks coming down
44		x		Operator	Stoppage must continue. Large block jammed at cylinder 22
48		x		Operator	Start up, large block released
51		x		Operator	Why have we stopped ?

Time	Person speaking: Operator	Person speaking: Overman	Person speaking: Other	Message from or for	Content
	x			Overman	Large blocks at the coal face bottom end
		x		Operator	What is pressure gauge reading?
	x			Overman	50 atm.
52	x				Loader belt stopped
12.02		x		Operator	Why have we stopped ?
03	x			Overman	Loader belt stopped
07		x		Operator	Why have we stopped ?
08			x	Overman	Large block at cylinder 17
13			x	Operator	Start
14		x		Operator	Do not start: large block still jammed at cylinder 15
18		x		Operator	Working may continue from cyl. 15
09		x		Chief overmen	What is your deviation from true direction ?
20		x		Operator	What is deviation at coal face bottom end from true direction?
20			x	Operator	Pull plough downwards and double plough once
22		x		Operator	Why have we stopped ?
	x			Overman	Large blocks jammed at cyl. 5
25		x		Operator	How long will this continue at cylinder 5 ?
26		x		Operator	Why has large block still not been released ?
27			x	Operator	Everything OK
28		x			What was the source of 5+1 signal?
	x			Overman	Large block jammed at cyl. 2
29	x			Coal face top end	Remove large blocks
29		x			Watch out for large blocks coming down
30		x		Operator	Start up
30			x	Operator	Do not start; large blocks still jammed at cylinder 2
37		x		Operator	Raise the plough
42			Superv.	Coal face top end	What is your deviation from true direction ?
45		x		Supervisor	Information on coal face situation
45			x	Operator	No more double ploughing
47			Superv.		Who told the man at cyl.19 to leave

Time	Person speaking			Message from or for	Content
	Operator	Overman	Other		
50	x				Loader belt has stopped
53	x			Coal face top end	Emergency stop switch actuated
57			x	Operator	No more double ploughing
59			x	Operator	Pull plough upwards
13.00		x		Operator	Stop plough
02			x	Operator	Raise plough towards coal face top end
08			x	Overman	What is the direction ?
09			x	Operator	What was the source of 5 + 1 signal ?
10			x	Operator	Stop plough
10			x	Operator	Re-start plough
15		x		Operator	What is deviation from true direction at coal face base ?
16			Superv.	Operator	What was source of 5 + 1 signal ?
16		x		Operator	Stop plough
23			x	Operator	Pull plough downwards
30	x				Stop loader belt
32			Superv.	Coal face top end	Content of message unknown
40			Superv.	Overman	What is coal face situation ?
44		x		Chief overmen	Information on coal face situation
45			x	Operator	1x double ploughing at cylinder 19 then deviate from specified direction by 3 m.

MORNING SHIFT

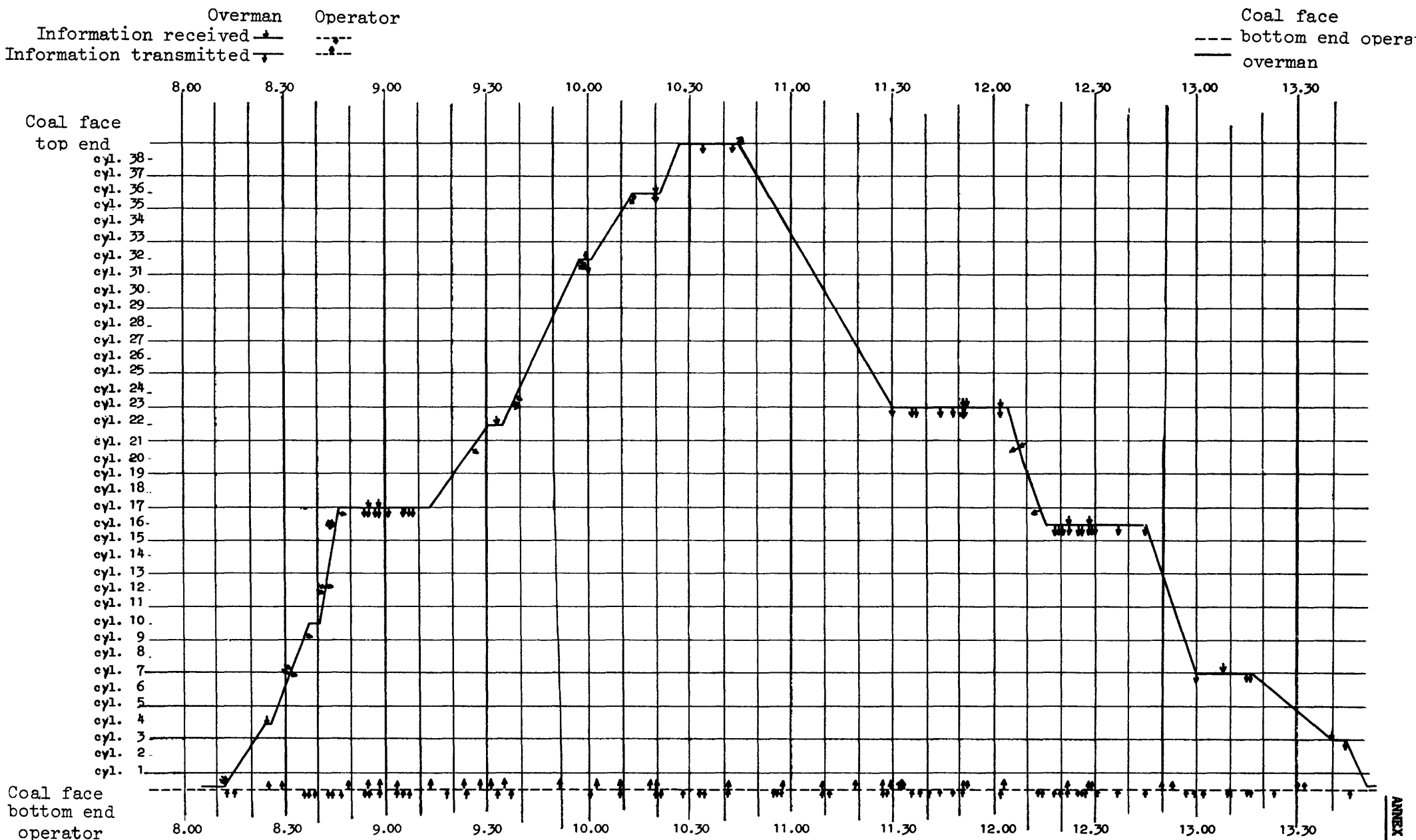


figure : Summary of times at which overmen and operator at bottom end of coal face were involved in communication over a distance (↗). The time is shown on the x-axis and coal face points (scraper cylinder numbers) on the y-axis. Situation after installation of loudspeaking telephone.

ANNEX IO

ANNEX 11

Summary of informational contacts between overman and operator at the coal face bottom end (after installation of loudspeaking telephone) - Afternoon shift.

Time	Person speaking: Operator	Person speaking: Overman	Person speaking: Other	Message from or for	Content
16.29		x			Is cylinder 13 manned ?
			x	Overman	Yes
35			x	Operator	Send shovel handle up
36			x	Operator	Stop ploughing briefly
37			x	Operator	Lower plough slightly
42		x		Chief overman	Shut off water, there is a leak at cylinder 14
42		x		Chief overman	Send Bahco spanner immediately
47			x	Operator	Do not plough
47		x		Chief overman	What is situation at coal face? (v.d. Heuvel)
48			x	Operator	Ploughing
50		x		Chief overman	What is situation at coal face ? (Doorneveld)
53		x		Chief overman	What is situation at coal face ? (Douven)
53			Chief overman	Overman	Cylinders 14 to 17 in coal
54		x		Operator	What is position with cap ?
56	x			Coal face top end	Emergency stop switch off; why?
58			x	Operator	Reduce pressure, the T junction has blown
17.00			x	Operator	Why has pressure not been reduced yet ?
00	x			Operator	The pressure is reduced
02			x	Operator	Restore pressure
04			x	Operator	Pull plough downwards
08			x	Operator	Large block jammed in line
10			x	Operator	Plough may be raised
11	x			Supervisor	Loading hopper must be operated by hand
11	x			Supervisor	Man needed to assist at loading hopper
13			Coal face top end		What kind of props are needed to fit at breakdown point ?

Time	Person speaking			Message from or for	Content
	Operator	Overman	Other		
15			x		Cylinder 20 defective
15			Coal face top end		No more props
16		x		Coal face top end	Information on props to be placed at breakdown point
19			x	Operator	Stop conveyor,large block jammed
20			x	Operator	Start conveyor, but do not plough
21			x	Operator	Plough
22		x			Deviation from true direction is 5 m.
23		x		Operator	Pull plough upwards
25			x	Operator	Raise plough slightly again
25			x	Operator	Large block jammed at cyl. 2
30			x		Microphone defective at cyl. 8
30			x	Operator	Run conveyor briefly
32			Superv.	Chief overmen	What is your deviation from true direction ?
32	x			Supervisor	3.60 m
32			Coal face top end	Supervisor	3.60 m
34		x		Chief overmen	What is your deviation from true direction ?
36			x		Release large block
42			x	Operator	There is a shovel in conveyor
45		x		Operator	Pull plough upwards to coal face top end
54			x	Operator	Stop conveyor, large block jammed at breakdown point
55			x	Coal face top end	Is new cylinder ready ?
55			x	Coal face top end	Send 30 oak blocks down
58		x			Why have we stopped ?
58			x	Overman	Remove new cyl. from conveyor
59	x				Stop loader belt, advance empty tubs
18.02			x	Operator	Inch forwards.Large block jammed
05			Superv.	Coal face top end	Have you found more props ?

Time	Person speaking: Operator	Person speaking: Overman	Person speaking: Other	Message from or for	Content
07	x				Large block jammed at coal face bottom end
15			x	Operator	What is situation at coal face bottom end ?
15		x		Chief overman	What is deviation from true direction ?
-			Chief overman	Overman	3.70 m
-			x	Chief overman	What is deviation from true direction at cylinder 30 ?
-			Chief overman	Overman	3.80 m
24	x				Why have we stopped at coal face?
-			x	Operator	Re-start
26			x	Coal face top end	When will blocks be sent down ?
-			Coal face top end		Immediately
30			x	Operator	Pull plough upwards
33	x				Large block jammed at coal face bottom end
18.35			x	Operator	Re-start plough
47	x				Stop loader belt
50	x				Second belt defective
55			Coal face top end		Once plough has been raised, props will start coming down
19.05			Superv.	Operator	Why have we stopped ?
30	x				Loader belt has stopped
37			x	Operator	Stop plough; large block jammed at cylinder 18
38			x	Operator	Go ahead
47	x				Send electrician to cylinder 7 to check microphone
48			x	Operator	Pull plough upwards
52		x		Chief overmen	What is your deviation from true direction ?
55	x				Large block jammed at coal face bottom end
55			x	Operator	Stop conveyor; flat rock on it

Time	Person speaking			Message from or for	Content
	Operator	Overman	Other		
20.09		x		Operator	Pull plough downwards
21			x	Operator	Why have we stopped ?
	x				Large block jammed in loading hopper
26	x				What was source of 5+1 signal ?
28			x		Cylinder 34 deviating from true direction by 4.5 m
29			Superv.	Operator	Indicate 5.50 m at bottom end
38			x	Operator	Inch plough upwards
39			x	Operator	Pull plough upwards normally
53			Coal face top end	Operator	Emergency switch actuated here
53			Superv.	Operator	What is deviation from true direction at coal face bottom end?
	x			Supervisor	5.60 m
54			x	Supervisor	Distance from cylinder 30 to top end 4.90 m
58			x	Operator	Stop briefly;large block jammed
21.15		x		Chief overmen	What is coal face situation ?
16			x	Operator	Double ploughing from deviation to coal face top end
30			x	Operator	Stop conveyor
31			x	Operator	Go ahead
32		x			Large block jammed at cyl. 18
34		x		Operator	Go ahead
36		x		Operator	Stop conveyor
-		x		Operator	Move 1 metre on
39			x	Operator	Continue
42			x	Operator	Plough must not return to coal face top end
43		x			Why have we stopped ?
45			Superv.	Chief overmen	What is coal face situation ?

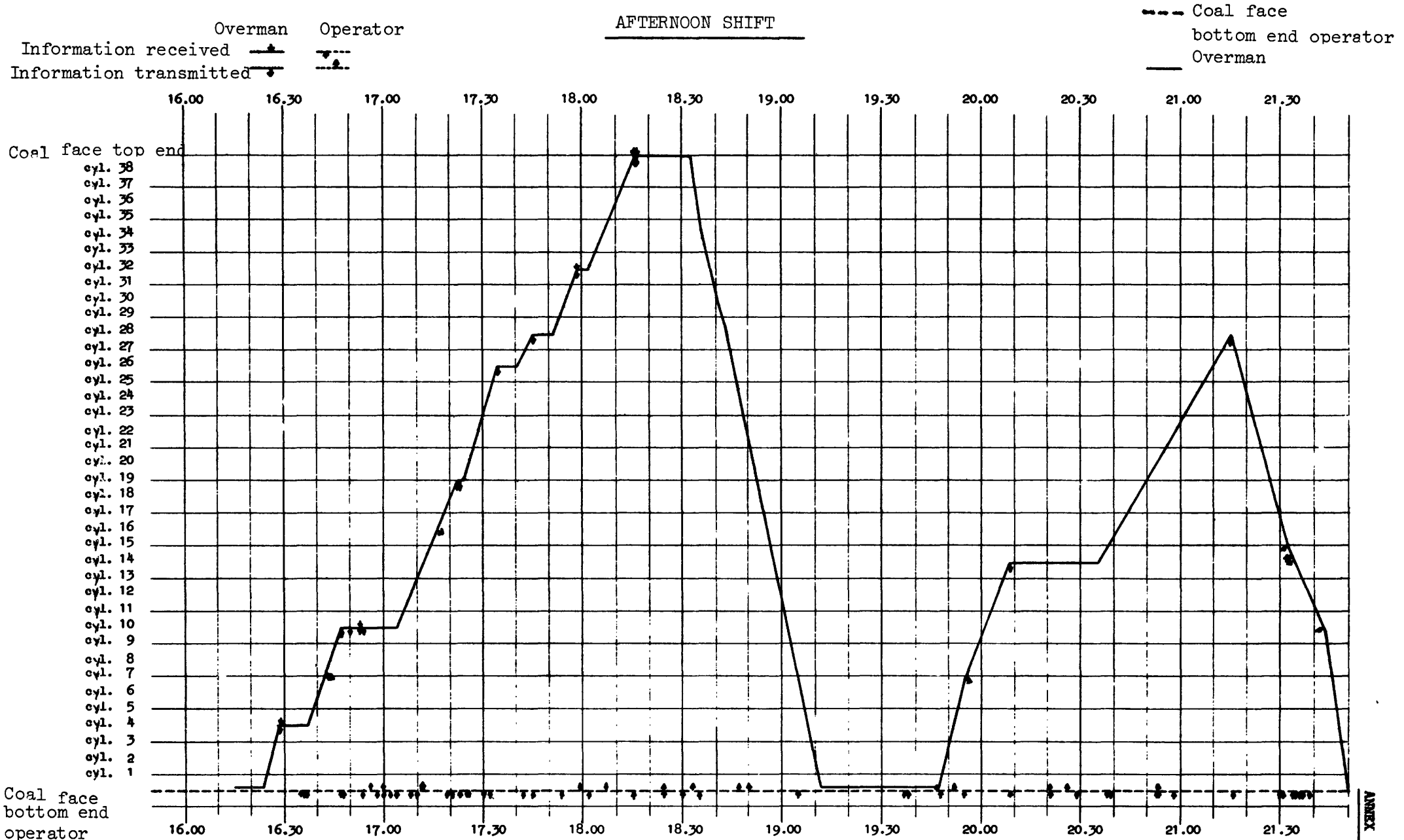


Figure : Summary of times at which overman and operator at coal face bottom end were involved in communication at a distance (*f*). The time is shown on the x-axis and coal face points (scraper cylinder numbers) on the y-axis. Situation after installation of loudspeaking telephone.

ANNEX 12