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SEVENTH REPORT OF THE MINES SAFETY AND HEALTH COMMISSION

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INTRODUCTION

The Seventh Report of the Mines Safety and Health Commission contains :

1. A synopsis of the activities of the Mines Safety and Health Commission and its Working Parties for 1969.
2. A recapitulation of the accident statistics for the years 1958 to 1969 with comments on their trend.
3. A study of the manner in which the Recommendations of the Mines Safety and Health Commissions have been implemented as at 1st January 1970.

Since progress in promulgating regulations is only reported on every two years, this does not feature in this Report.

The items listed on the preceding page have been relegated to the annex.

SECTION I

ACTIVITIES OF THE MINES SAFETY AND HEALTH COMMISSION

In 1969 the Mines Safety and Health Commission held one meeting, the Restricted Committee three, the Working Parties and their Sub-Committees: 39. In addition, the Secretariat of the Mines Safety and Health Commission organised or gave its support to four informational meetings for interested trades unions. The overall total was therefore 47 (32 in 1968) covering 59 days, several meetings having lasted 2 days.

The breakdown of the meetings of the Working Parties and their Sub-Committees is as follows:

Rescue arrangements, Mine Fires, Underground Combustion:	6
Rescue arrangements:	2
Ventilation Sub-Committee:	6
Shaft-fires Sub-Committee:	2
Fire-resistant fluids Sub-Committee:	3
Winding and guide ropes:	2
Electricity:	11
Joint accident statistics:	3
Health:	3
Psychological and sociological factors affecting safety:	1

This large number of meetings has, nevertheless, not resulted in conclusions capable of being adopted by the Mines Safety and Health Commission. However, some technical reports were accepted and distributed, such as the report on cables serving mobile machines underground and their protection, the description of a new method of fatigue-testing winding ropes, a note on the use of foamed polyurethane underground together with the criteria which this product, or any other substance used for the same purpose, has to satisfy and the bi-annual report on rescue stations. These reports are annexed.

In addition, the Joint Accident Statistics Working Party has nearly finished drawing up a body of statistics covering both light accidents and the pits accidents and nature of the injuries, while the Health Working Party has initiated three reports on methods of dust suppression; these it submitted to the Restricted Committee which expressed the wish that they become the subject of Recommendations.

Within the framework of the exchange of information provided by the Commission of the European Communities, the Secretariat of the Mines Safety and Health Commission organised or assisted 4 one-day conferences of the interested trade unions at Essen, Heerlen, Autrans and Luxembourg, at which the latest results of the Mines Safety and Health Commission were made known.

Lastly, the Mines Safety and Health Commission, at ist meeting on 20 June 1969, took note of the Resolutions (Official Journal of the European Parliament, doc. 207) adopted by the European Parliament at its session in May 1969 after it had considered the Fifth Report on activities of the Mines Safety and Health Commission (for the year 1967).

It was notified of the large number of interventions made concerning this report and of the explanations given by the Chairman, M. LEVI SANDRI. The Mines Safety and Health Commission decided to take into account, as far as at all possible, the wishes of the European Parliament, and instructed the Secretariat to prepare draft terms of reference for studying environmental factors, the medical aspects of dust suppression methods and the problems involved in the safety-training of foreign workers.

It adopted the wish of the Parliament to launch a comparative study of mining regulations in force in member countries, and to prepare a list of Community equipment for the rescue of those trapped by means of large-diameter boreholes.

In 1969 the Secretariat embarked on the preparatory work for these new tasks, bearing in mind any possible results from research already in hand within the Commission.

The European Parliament, at its session of 27 November 1969, studied the Sixth Report of the Mines Safety and Health Commission for 1968, but its Resolutions could not be discussed within the Mines Safety and Health Commission during 1969. These Resolutions included the previous ones and, in addition, called for a study of falls of ground, mechanisation and ventilation, the latter comprising the study of the use of detectors and particularly those detecting oxygen-deficiency.

As in previous Reports, this first section sets out to survey, as concisely as possible, Working Party by Working Party, the origin of the work, development of the work during the meetings in 1969, and any results obtained in certain work, together with the outstanding problems.

I. TECHNICAL PROBLEMS

A. Rescue arrangements, Mine Fires, Underground Combustion

The full Working Party held three Plenary Meetings, one of these at Essen, and three restricted preparatory meetings.

The rescue experts who were members of this Working Party met on two occasions, one being a visit to the rescue centre of the Sulcis coalfield.

Eleven meetings of experts were also held on the stabilisation of ventilation, fire-resistant fluids and shaft fires.

This work continued the implementation of established terms of reference, to which number were added, among other subjects, ventilation problems, thereby complying with the wishes expressed by the European Parliament. This list of terms of reference is annexed.

They appear below in the order already established in previous Reports, which is not necessarily an order of priority.

1. Shaft fires

The work of this Sub-Committee which started after the MARCINELLE disaster in 1956 included, among other things, the experimental extinguishing of a test fire in an abandoned shaft at DORSTFELD in 1964 and various water injection tests in shafts.

To be able to complete the re-appraisal of the Recommendation of the Mines Safety and Health Commission of 8 April 1960 (1) regarding the extinction of shaft fires, it was necessary to re-assess the value of the aeromotor effect of water falling down a shaft, which is shown in graph form in this Recommendation, discrepancies having been noted in the practical tests carried out at the Arenberg-Fortsetzung pit (Germany), RESSAIX (Belgium) and later in Czechoslovakia.

The two experts in charge of the tests at ARENBERG and RESSAIX agreed, first, on a programme of water injection in a shaft about to be abandoned at RESSAIX and then started the tests themselves. Evaluation of the results is in hand and the conclusions should be submitted during 1970.

(1) Second Report of the Mines Safety and Health Commission, page 26 (French text).

2. Fire-resistant fluids

With regard to flame propagation in a mixture of coaldust and fire-resistant oil (cf. Sixth Report, page 8), the results obtained at the 4 experimental stations in the Community have shown up discrepancies. During comparative tests at two of these stations all those conducting the tests were able to identify the most significant factors from among the slight variations in equipment and methods prevailing despite the joint criteria adopted. Uniform criteria are being drafted.

3. Foamed polyurethane seals

The Working Party studied an experts report, recapitulating the test results at the HASSELT (Belgium) Centre de Coordination des Centrales de sauvetage, the experimental TREMONIA pit at Dortmund (Germany), the Buxton Experimental Establishment of the Safety in Mines Research Establishment (United Kingdom) and taking into account the circumstances of the fire at Michael Colliery (Fife) in the United Kingdom (Sixth Report, page 9).

The Working Party drafted a Note (cf. Annex) in which it reconsiders the sealing properties of this material and the multiplicity of its applications in mines, which are advantageous to either safety or health: seal stoppings, sealing of roadway walls, insulation of certain mains.

It stresses also the inherent dangers: the possibility of spontaneous combustion when applied in too thick coatings; very rapid flame propagation when the foam is applied as a stopping throughout the roadway leading to large-scale production of dangerous fumes with a low oxygen content; danger of electro-static charges.

Having weighed these advantages and risks and the means of largely obviating them, the Working Party considers that this material cannot be banned but can only be used with reservations, the permissible applications and circumstances being known to those in charge.

Finally, the Working Party established a list of criteria, for the benefit of the chemical industry concerned, to which this or a similar material should conform so that it may be used without reservations underground, the main criterion being that the material should be fire-resistant without the addition of a special fire-resistant or plaster coating, even if it is applied as a stopping.

4. Rescue by means of large-diameter boreholes

In 1968 the Mines Safety and Health Commission approved a proposal for experiments at Community level to investigate unsolved problems regarding the drilling of large-diameter rescue holes underground, in pursuance of Article 5 of its terms of reference, it proposed to the Commission of European Communities that these tests be carried out (cf. Sixth Report of the Mines Safety and Health Commission, page 9).

In 1969 the Centre d'études et de recherches des charbonnages de France (CERCHAR) in Paris and the Steinkohlenbergbauverein in Essen submitted their request for financial support for these tests, which was granted at the end of 1969. This work is now in hand.

5. Ventilation

Practical conclusions on applying the theory of stabilisation of ventilation (Sixth Report, page 10) were sent to the Governments and to interested circles in 1968 for appropriate action.

These conclusions aroused considerable interest and were the subject of courses and information meetings in 1969 before being put into operation, and were also considered elsewhere, as had been agreed by the Mines Safety and Health Commission.

So it was that the Committee of Experts met, at the Centre de Calculs des charbonnages du bassin de Lorraine, the Ventilation Committee of the Steinkohlenbergbauverein, Essen, to consider the objection raised by the latter that the conclusions had in part been outstripped by modern computing methods: computers and ventilation simulation systems. The experts of the Mines Safety and Health Commission, on the other hand, believed that it was essential to understand the theory of ventilation stabilisation (1) and that the information derived from these conclusions was necessary even in cases where a computer was to be used, since this would enable the questions to be correctly put to the computer and to assess validly the usefulness of its replies, in the light of the latest knowledge in the field of ventilation stabilisation.

In addition the Committee of experts continued the study of these problems which had been left in abeyance in its documentation, dealing primarily with the degree of instability of roadways diagonal to ventilation (with or without underground fires being present, and the thermodynamic effects of a fire occurring in mine workings with descentional ventilation; on this subject it will make use of the results of tests carried out at the experimental TREMONIA pit at Dortmund.

6. Requirements for fire-resistant clothing

The Working Party was given these terms of reference as a result of the MONT-CENIS disaster at HERNE-SODINGEN (cf. Fifth Report of the Mines Safety and Health Commission, page 16).

The Working Party began the study of this question by examining, in cooperation with the Occupational Medicine department, the research work subsidised by the Community to develop protective clothing for the Iron and Steel industry intended against constant sources of heat, whereas in coalmines clothing needs to protect the rescue worker during his rescue operations against high temperature flame (1 300°) present for a relatively short space of time (several seconds) and subject to relatively low pressure. Existing and subsequently improved clothing was then tested at the Rescue Centre at ESSEN-KRAY in conjunction with the manufacturers, where both dummies and wearers were exposed to a flame of ignited lignite, measurements being taken on the surface of and inside the clothing itself. The outcome was that clothing of existing man-made fibres should, in order to protect the wearer against the heat of the flame, be worn with cotton underclothing which has the drawback of retaining the body heat of the rescue worker and hindering him in his work.

Tests were also carried out at the Rescue Centre at MERLEBACH with a powerful dust explosion, while rescue operations were being tried out in conditions of high thermal charges at the Centre de Sauvetage at HASSELT where research is being carried out on ways of cooling down the rescue worker.

The members of the Working Party and a restricted group of specialists were present at these tests at ESSEN and did some work on establishing criteria with which fire-resistant clothing should comply, taking into full account the very special conditions in which this clothing is used by rescue workers. This work is not yet completed.

7. Rescue arrangements

The rescue experts took note of a hydromechanical method of constructing plaster stoppings developed by the Rescue Centre of the SAARBERGWERKE AG.

A method of constructing plaster stoppings had previously, as the result of tests financed by the High Authority and conclusive try-outs, been the subject of regulations governing the construction of such stoppings established by the ESSEN-KRAY Centre and approved in 1964 by the Mines Safety and Health Commission (Annex X to the Third Report).

The hydromechanical method is a development of the earlier method: a special plaster is used, which can be stored for one year, and this is injected in liquid form after mixing in a special mixer. The construction of the stopping and the setting time of the plaster are even quicker than by the dry method, or the mixing of water and plaster on site. The resistance of the stoppings to explosion is ensured in a shorter space of time and the distance between the stopping and the majority of the men is further increased: it is normally up to 500 m with a throughput of 7 m^3/hour.

The Directors of Rescue Stations and some experts studied the Seventh Report of Rescue Arrangements for 1967 and 1968 in Community countries and the United Kingdom and noted amendments adopted at the Centres, new equipment and lessons to be learnt from accidents which occurred during rescue work.

In the Sulcis coalfield in Sardinia they visited the fully mechanised Seruci pit and embarked on an exchange of information on safety and rescue services and the equipment available to these.

B. Winding ropes and shaft guides

The Working Party noted the decision of the Mines Safety and Health Commission (Sixth Report, page 10) and considered that, from the safety point of view, there was value in carrying out a test programme on the dynamic stresses on shaft guides. This note by the Mines Safety and Health Commission had been forwarded to the branch of the Commission engaged on mining research and concerned with the request for financial aid originating from the experimental TREMONIA pit for carrying out tests in this field.

The synoptic summary covering the regulations at present in force in Community countries and the United Kingdom with regard to cage suspension gear was submitted to the Restricted Committee. To this summary a note will be added indicating to what extent the regulations existing on national levels should be elaborated or to what extent minimum standardised regulations should be the subject of a Recommendation of the Mines Safety and Health Commission.

The Working Party took note, as part of its terms of reference, of a new method developed by the "Institut für Fördertechnik und Werkstoffprüfung der Seilprüfstelle der Westfälischen Berggewerkschaftskasse" of Bochum for studying the fatigue in winding ropes. This method enables the dynamic stresses to be measured which, before now it was not possible to determine exactly. In this device, comprising three pulleys and a pulsator, the ropes are subjected to various lengthy dynamic stresses approximating actual stresses.

Numerous tests on thin haulage ropes in roadways were carried out and tests on thick winding ropes have been started. These have featured in an interim report, accepted by the Restricted Committee (1), which was distributed to interested circles because of the novelty of the method; it is annexed.

C. Electricity

The Mines Safety and Health Commission has accepted for distribution the "Report on the characteristics and the electric protection of cables supplying mobile machines (coal cutters, power loaders, etc.) used underground in coalmines in the different Community countries" as stated in the Sixth Report, page 11. This report is annexed.

Due in part to the dangers arising from the great forces to which cables are subjected and in part to the technical nature of this important documentation which makes it a domain of specialists, the Mines Safety and Health Commission has requested the Working Party to abstract from this study, conclusions of broader application which could serve as recommendations. During several restricted meetings it

(1) and by the Mines Safety and Health Commission on 21 February 1970.

proved possible to identify minimum requirements taking into account the relative importance of the many faults to which cables are prone; these will be submitted to the Mines Safety and Health Commission in 1970.

In addition, the Working Party has nearly completed the study of the terms of reference already mentioned in the Sixth Report:

- on the subject of the effect on electrical equipment underground of hygroscopic salts used for fixing coal dust, it took note of the reports on the experience collected underground in West German pits, on the Community-aided research carried out at the Versuchsgrubengesellschaft of Dortmund and on the laboratory tests carried out in France; the final report will be completed in 1970.
- it has utilised the extensive documentation on surges in underground workings due to lightning, available from Eastern Countries and Community Countries, and a report on the firedamp explosion at Mainsforth Colliery (United Kingdom) on which the terms of reference were based; the final report is nearly completed.
- the Working Party has compared the safety measures adopted in the Community and the United Kingdom on trolley locomotives underground and in particular on the possibility of reducing the incidence of trolley sparks; the final report is nearly completed.

Finally, the Secretariat has assembled material on the composition of electric cables for tensions up to 6 000 volts and protective devices for these, which each delegation on the Working Party has prepared for its own country; this subject will be dealt with starting early in 1970.

D. Flammable dust

The programme of joint research for studying dust explosions requested by the Mines Safety and Health Commission, the effectiveness of barriers in large cross-sections, weak and very powerful explosions and the adaptation of these barriers so that they do not impede normal roadways activity has continued to be the subject of research in two institutes of the Community.

The Secretariat has received the latest results of this research which will be submitted to the Working Party in 1970. The latter will also study the circumstances of two explosions whose characteristics were obtained and notified as a result of a questionnaire issued by the Working Party in 1968.

E. Joint Accident statistics

The Working Party has continued the work started in 1968 referred to in the Sixth Report, page 12.

Having investigated the distortions which might occur as between countries in the Community classification employed since 1958 for the recording of fatal and serious accidents according to their causes, the Working Party found that the discrepancies were insignificant and did not detract from the validity of these statistics.

The Working Party has also prepared two tables. One gives a breakdown of accident victims underground according to where they occurred (mine workings, drivages, shafts and staple pits, other sites), to their degree of seriousness (involving absences of from 4 to 20 days, 21 to 56 days and fatalities) and the 12 categories of causes which are the same as those used for surveys since 1958 with slight modifications made in the light of the analysis referred to above.

The second table gives a breakdown of victims according to the place of the injuries, the nature of the injuries and the gravity of the accident: over 56 days absence or fatality.

Before submitting the results of this work to the Mines Safety and Health Commission the Working Party has still to assess the statistical validity of these findings, that is, to incorporate the rates (in millions of working hours) established, with due weighting for reliability, which will make possible a comparison of the different rates with regard, on the one hand, to their trend in time and, on the other, to their statistical significance.

F. Study of accidents

In 1969 the Mines Safety and Health Commission was informed of five accidents and studied supplementary reports on two accidents which occurred in 1968.

a) Accident in the Gérard shaft at the Gardanne Colliery in the Provence coalfield - 25 February 1969 - massive fall of ground - six killed.

A provisional report on this accident was made to the Mines Safety and Health Commission.

Whilst waiting for the final conclusions of the inquiry, it is possible to summarise the main circumstances as follows :

A heavy and sudden fall of ground occurred at a depth of 600 metres in a roadway being driven using a continuous miner in a level seam of lignite 5 metres in thickness with a sound roof. This seam was being worked by the room and pillar method and was 100 metres in length and between 7 and 10 metres in width. The fall occurred when a residual pillar was being driven between two faces already worked and hydraulically stowed, in a seam thickness reduced to 3.5 metres due to convergence. The six miners engaged on heading work were buried where they were. The causes are not yet proven but the following facts have been established :

- the fall was accompanied by coal bursts; tremors were felt on the surface;
- the two stowed rooms either side of the disaster roadway were not crushed;
- the safety seam had been partially worked previously in this section due to the local working out of this seam.

b) Accident in pit 10 of the Escarpelle in the Douai group of the Nord et Pas-de-Calais coalfield - 24 March 1969 - fall of cage in a staple pit - 5 killed.

A cage used for material in an interior shaft of 90 metres in depth suffered a virtual free-fall of that distance, probably as a result of an unfortunate action by the winder, who stated that he was unaware there were five fitters in the cage. The shaft was equipped with ladders and the use of the cage by men was forbidden. The shaft winding gear was of an old type, worked by compressed air and equipped with two drums one of which could be disengaged.

The accident will be the subject of a final report when the inquiry is completed.

c) Accident at the Emil Emscher Colliery at Essen-Altenessen (Ruhr) - 2 October 1969 - heavy fall of ground - 4 killed, 5 rescued.

Even though in this accident less than 5 people were killed, it was the subject of a report to the Restricted Committee due to the interest it presents from the viewpoint of rescues by means of large-diameter boreholes.

It occurred in a face 120 metres in length working a steep seam (789) 1,8 metres in thickness using straight steps 3.25 metres in height with wooden supports. The bottom roadway, 9 m^2 in cross section with metal arches was driven 40 metres in advance of the face and 54.6 metres in advance of the pillar.

As a result of a roof slip, the coal and the roof of the five lower steps fell in, blocking the bottom roadway for a stretch of 31 metres, 5 miners finding shelter in the advance heading of the lower part of the roadway and 4 others remaining in the fall area.

The rescue of those entombed was effected by the classical method for cases of this kind: the drivage of a roadway under the bottom road using the latter's tracks as a roof. It was completed in 3 days.

At the same time, as from the gate road - and at a point where the height happened to be sufficient, a 193 mm diameter borehole was drilled downwards through the coal, the coal being brought up at the sides with the injected water. This borehole reached the trapped men after 23 hours work but became blocked up when the drill-rod was withdrawn. A second 62 mm diameter borehole which was later to have been widened to a diameter of 500 mm to allow the passage of the rescue capsule, was also drilled as a cross-cut from another roadway at a higher level and reached the point of the trapped men, but only after they had been rescued.

The difficulties encountered were of a type which, among others, gave rise to a request for Community tests as noted in paragraph 4.

The following two accidents were not studied by the Mines Safety and Health Commission because they did not have 5 victims and did not appear to promise useful information on Community level. The Secretariat of the Mines Safety and Health Commission has, however, been notified of these, together with a brief account of the circumstances. In addition, these accidents were the subject of condolences on the part of the Mines Safety and Health Commission and Community financial assistance to the families of the victims.

The accidents in question appear below under d) and e).

d) Accident at the Barrois mine at Pecquencourt of the Douai group in the Nord et Pas-de-Calais coalfield - 28 November 1969 - 4 killed.

A heavy fall of ground occurred in a short steep face 20 metres in height, being worked experimentally by "hydraulic shotfiring", a method which consists of forcing into the coal, during water injection, an additional quantity of water under 500 atm pressure, which cracks the coal and enables it to be won without dust.

e) Accident at the Rossenray Colliery at Kamp-Lintfort (Ruhr) - 27 October 1969 - fall of ground - 4 killed.

A fall of ground occurred during the starting up of a roadway leading from a main roadway; for reasons as yet unknown the supports at the roadway junction, together with some 3 metres of overburden, collapsed on the 4 miners.

f) Accident at the "Minister Aschenbach" Colliery (Ruhr) - 4 October 1968 - firedamp and coaldust explosion - 17 killed - (cf. Sixth Report, page 13).

The Mines Safety and Health Commission has examined a provisional report on this accident. Whilst waiting for the final conclusions of the research carried out at a number of institutes in the Ruhr and the conclusions of the inquiry itself, it is possible to summarise the circumstances of this accident as follows:

It occurred in a caved face which had been started up 4 days previously in a slightly inclined seam between 1.6 and 1.8 metres in thickness. In order to initiate caving of the roof, which was of sandy shale, shotfiring had been carried out in the roof of the face, the shots having been halted two hours before the explosion. The shots had caused a violent roof fall in the caving zone and heavy pressure at the coalface, especially in the lower part which had advanced 15 metres in relation to the original rise heading, slewing round the upper part.

The second report deals with the specialised services entrusted with monitoring dust levels in underground workings.

Taking into account the main regulations in force in the countries of the Community and the United Kingdom, the report formulates - with a view to achieving a degree of uniformity in the way in which these services operate - a number of criteria to which they should conform, both in their composition and their procedures.

The third report's purpose is to reduce dust levels resulting from the use of coalwinning and road heading machines. It recommends close collaboration between manufacturers, mining and research services or centres from the initial design to the development of these machines. In this way the set-backs and difficulties will be avoided which previously arose with the introduction of machines well-designed from the point of view of their economic performance but unacceptable on account of the dust levels produced.

The Restricted Committee (1) has requested that these draft reports be further amended.

B. Psychological and sociological factors affecting safety

The Secretariat has collated documentation on continuous transport systems and their use to finalise the safety campaign referred to in the Sixth Report, page 15. This documentation comprises illustrated compilations describing armoured and belt conveyors and the protection they can be afforded at present and the regulations and proper handling instructions for all continuous transport systems; it also contains a list of audio-visual and film material available in the Community which will be offered to those taking part in the safety campaign. These different documents will be condensed and where necessary supplemented with a view to their distribution.

A detailed programme for the practical conduct of such campaigns has been devised by the Secretariat and studied by a group of experts before being submitted to the Working Party which will study it in 1970.

The programme comprises the organisation of the different stages of this campaign which can be grouped into stages of preparation, execution and evaluation of results.

The preparatory stages are in hand both in the Secretariat of the Mines Safety and Health Commission and in the different coalfields.

(1) and the Mines Safety and Health Commission on 26 February 1970

SECTION II

JOINT ACCIDENT STATISTICS

As in previous Reports, the statistical tables reporting serious and fatal accidents which occurred in the various Community coalfields in 1968 have been placed in a separate annex; they are as usual, classified by cause of accident for the various coalfields, the member countries and the Community.

The presentation of the recapitulary information reproduced below is also identical with that used in previous years. In Tables A and B below, the information is grouped by cause of accident for the Community countries from 1958 to 1969; table C, using the same sub-divisions, shows the fatalities and seriously injured from 1960 to 1969 for group accidents, i.e. those which cause the death or serious injury to to more than five victims.

The graphs E - K present the data mentioned above for all accidents, including group accidents; they are intended to show a particular statistical trend, and even perhaps a certain degree of variation.

The Working Party for "Joint Statistics for Mine Accidents" continued its work in 1969. It has found that the discrepancies which may arise from a different interpretation of the classification system established by the Mines Safety and Health Commission in 1958, are insignificant and do not basically invalidate the earlier statistics. It is currently examining to what extent it is possible to establish, from the statistical viewpoint, a chronological comparison of the accident rates for each of the countries and for the Community, on the one hand, and a comparison as between the countries, on the other. The comments which follow, therefore, are subject to reservations while awaiting the completion of this work.

Let us, first, examine as in the previous reports the number of fatalities and serious casualties per number of tonnes extracted (Table D), this being done purely for indicative purposes, as has been stated previously, the level of safety being determined rather per million hours worked, as will be seen below.

As this Table and graphs I and K show, production in the Community fell off in 1969 by only 2 % (as against 4 % in 1968) and the number of hours worked by 9 % (11 % in 1968), while the o.m.s. rose by 6.5 % (7 % in 1968).

The number of fatalities per million tonnes fell from 1.32 in 1968 to 1.18 in 1969 (more than 3 in 1958) and the same rate for serious casualties, after undergoing a reduction of one-third from 1958 to 1967, showed a levelling-out in 1968 which was maintained in 1969 (40.82 against 41.4 in 1968).

A look at the number of fatalities per million working hours (Tables B, D and graph E) shows that:

The rate of fatalities is the lowest since 1958 and seems to confirm the levelling-out noted for 1967 and 1968. In absolute terms, the number of fatalities has continued to fall off, dropping from 240 in 1968 to 209 in 1969, i.e. a reduction of approximately 13 %, while the number of hours worked also dropped from 522 to 476 millions, i.e. reduction of approximately 9 %. In 1969, the accidents classified under headings I to V (Table B and graphs E and G) caused 94 % of the total fatalities (84 % in 1968) and are distributed as follows: Cause I (roof falls): 40 % (35 % in 1968); Causes II and III (haulage and transport, and movement of personnel): 42 % (37 % in 1968); Causes IV and V (machinery, handling of tools and falling objects: 12 % (12 % in 1968).

The number of serious casualties per million hours worked appears in Table A and graph F. The rate of incidence of 15.160 is increasing compared with 1968 and is now at its highest level since 1958. As before, it will be noted that there is the same predominance of the accident rates for categories I to V: 97 % of the total of serious casualties, distributed in three roughly equal parts: category I (roof falls) 29.5 %; categories II and III (haulage and transport, and movement of personnel) 34 %, and categories IV and V (machinery, handling of tools and falling objects) 33.5 %. As shown by graph H, the roof falls are still the most important cause of accidents; this accident rate, running against the general trend towards a reduction noted up to 1967, has continued to rise since then, recording a new increase of 5.5 % compared with 1968.

The rates for categories II and III which also showed a trend towards reduction, also rose by 4 % in 1969. The rates for categories IV and V have continued to rise, as during previous years, this increase being 8 % in 1968 and 6 % in 1969.

A. Comparative Table of

numbers of persons incapacitated by underground accidents

for eight weeks or longer

years 1958-69

per '000,000 man-hours

CAUSE (1958-1964)	Germany							Belgium							France (excl. Provence)						
	1958	1959	1960	1961	1962	1963	1964	1958	1959	1960	1961	1962	1963	1964	1958	1959	1960	1961	1962	1963	1964
1) Falls of ground	4.843	4.779	4.886	4.797	4.682	4.663	4.894	5.911	4.294	4.324	4.071	4.439	4.432	4.417	5.027	4.665	4.774	4.416	4.222	4.177	4.308
2) Haulage and transport	2.550	2.569	2.445	2.458	2.501	2.433	2.385	4.132	2.979	2.709	2.770	3.331	3.565	3.419	1.980	1.695	1.920	2.106	2.196	2.364	2.278
3) Movement of personnel	2.497	2.463	2.348	2.512	2.608	2.646	2.744	1.354	0.998	1.008	1.062	1.136	1.066	0.961	1.505	1.118	2.873	2.334	2.458	2.368	2.383
4) Machinery, handling of tools and supports	0.767	0.914	0.920	0.867	1.046	1.213	1.242	2.804	2.085	2.386	2.097	2.461	2.414	2.310	0.914	1.022	1.621	2.523	2.991	3.096	3.042
5) Falling objects	2.537	2.719	2.738	2.945	3.077	3.038	3.242	0.414	0.371	0.354	0.301	0.445	0.547	0.397	1.890	2.187	1.893	2.292	2.073	2.278	2.074
6) Explosives	0.015	0.011	0.010	0.009	0.008	0.006	0.006	0.027	0.007	0.032	0.018	-	0.019	0.018	0.043	0.051	0.031	0.017	0.051	0.009	0.013
7) Explosions of firedamp or coal dust	0.011	0.016	-	0.002	0.123	0.010	-	-	-	-	-	-	-	0.009	0.047	0.088	-	-	0.004	-	-
8) Sudden outbursts of firedamp, suffocation by natural gases	-	-	-	-	-	-	-	0.011	-	-	-	-	-	-	0.004	-	-	-	-	-	-
9) Underground combustion and fires	-	-	0.003	0.002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10) Inrushes of water	0.004	-	-	-	-	0.004	-	-	-	-	-	0.010	-	-	-	-	-	-	-	-	0.018
11) Electricity	0.010	0.014	0.012	0.014	0.006	0.012	0.009	0.011	-	0.016	0.018	0.010	0.009	-	0.014	-	0.004	0.029	0.004	0.014	0.009
12) Other Causes	0.487	0.522	0.457	0.503	0.488	0.473	0.477	0.260	0.255	0.260	0.301	0.351	0.198	0.268	2.956	2.768	0.793	0.362	0.240	0.354	0.227
TOTAL	13.721	14.007	13.819	14.109	14.539	14.499	14.999	14.924	10.989	11.089	10.638	12.161	12.250	11.799	14.380	13.594	13.909	14.079	14.239	14.660	14.347

CAUSE (1958-1964)	Italy							Netherlands							Community						
	1958	1959	1960	1961	1962	1963	1964	1958	1959	1960	1961	1962	1963	1964	1958	1959	1960	1961	1962	1963	1964
1) Falls of ground	1.355	1.378	1.808	-	0.792	0.366	0.893	1.326	1.464	1.305	1.829	2.238	1.742	2.017	4.846	4.490	4.571	4.434	4.387	4.337	4.509
2) Haulage and transport	1.335	0.984	1.205	0.676	1.847	1.465	1.787	1.511	1.562	1.898	1.924	2.590	1.826	1.952	2.602	2.347	2.310	2.371	2.521	2.520	2.346
3) Movement of personnel	0.668	0.394	1.005	1.578	1.056	0.732	1.787	0.324	0.386	0.187	0.514	0.580	0.630	0.472	2.003	1.823	2.185	2.185	2.282	2.261	2.326
4) Machinery, handling of tools and supports	1.169	0.984	0.603	0.902	1.584	1.465	3.127	0.617	0.402	0.780	0.915	1.015	1.050	1.094	1.098	1.064	1.264	1.423	1.712	1.818	1.848
5) Falling objects	1.169	1.698	1.808	2.029	2.375	3.296	3.574	0.401	0.515	0.492	0.819	0.642	0.630	0.923	1.962	2.161	2.105	2.353	2.375	2.406	2.442
6) Explosives	0.167	-	-	0.225	-	0.366	-	-	-	-	-	-	-	0.021	0.023	0.020	0.017	0.012	0.018	0.010	0.011
7) Explosions of firedamp or coal dust	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.017	0.030	0.010	0.001	0.071	0.006	0.001
8) Sudden outbursts of firedamp, suffocation by natural gases	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.002	-	-	-	-	-	-
9) Underground combustion and fires	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.002	0.001	-	-	-
10) Inrushes of water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.002	-	-	-	0.001	0.002	0.003
11) Electricity	-	-	-	-	-	-	-	-	-	-	-	0.021	-	0.021	0.010	0.008	0.010	0.018	0.007	0.012	0.008
12) Other Causes	0.334	0.591	0.603	0.451	-	-	-	0.262	0.161	0.390	0.210	0.497	0.147	0.129	0.985	1.012	0.513	0.428	0.404	0.390	0.364
TOTAL	6.197	6.299	7.032	5.861	7.654	7.690	11.168	4.441	4.490	5.051	6.212	7.583	6.025	6.629	13.551	12.954	12.986	13.227	13.781	13.781	13.861

(1965-1969)	Germany							Belgium							France (excl. Provence)						
	1965	1966	1967	1968	1969	1970	1971	1965	1966	1967	1968	1969	1970	1971	1965	1966	1967	1968	1969	1970	1971
1) Falls of ground	4.732	4.721	4.524	4.618	4.736			3.574	3.568	3.850	3.676	5.075			3.941	3.927	3.634	4.162	4.044		
2) Haulage and transport	2.411	2.067	1.913	1.994	2.195			2.866	3.269	2.960	3.220	3.169			2.153	1.858	1.918	1.946	1.556		
3) Movement of personnel	3.032	2.852	2.974	3.300	3.399			0.771	0.936	0.903	1.122	1.186			2.087	2.239	2.174	2.815	3.226		
4) Machinery, handling of tools and supports	1.234	1.244	1.124	1.396	1.291			2.126	2.146	2.265	1.903	2.353			2.272	2.639	2.773	3.016	3.070		
5) Falling objects	3.344	3.272	3.642	3.773	4.036			0.292	0.349	0.459	0.358	1.244			1.839	1.785	2.114	2.386	2.537		
6) Explosives	0.005	0.005	0.017	0.011	0.007			-	0.013	0.056	0.049	-			0.037	0.010	0.011	-	0.050		
7) Explosion of firedamp or coal dust	0.014	0.013	-	0.004	0.004			0.031	-	-	-	0.019			-	0.029	-	-	-		
8) Sudden outbursts of firedamp, suffocation by natural gases	0.005	-	0.003	-	-			-	0.013	-	-	-			-	-	0.005	-	-		
9) Underground combustion and fires	-	-	-	0.004	-			0.021	-	-	-	-			-	-	-	-	-		
10) Inrushes of water	-	-	-	-	-			-	-	-	-	-			-	0.005	-	0.006	-		
11) Electricity	0.002	0.010	0.006	0.011	0.026			0.010	0.013	-	0.016	0.019			0.014	-	0.005	0.006	0.014		
12) Other Causes	0.354	0.414	0.396	0.429	0.402			0.333	0.362	0.278	0.228	0.175			0.174	0.200	0.185	0.233	0.291		
TOTAL	15.133	14.598	14.599	15.540	16.096			10.024	10.669	10.771	10.572	13.240			12.517	12.692	12.819	14.570	4.788		

(1965-1969)	Italy							Netherlands							Community						
	1965	1966	1967	1968	1969	1970	1971	1965	1966	1967	1968	1969	1970	1971	1965	1966	1967	1968	1969	1970	1971
1) Falls of ground	5.572	6.360	5.580	0.812	3.656			1.923	1.688	2.466	2.450	2.737			4.215	4.186	4.060	4.261	4.492		
2) Haulage and transport	-	0.707	0.797	0.812	-			2.808	2.621	1.866	2.407	2.562			2.416	2.173	2.037	2.139	2.118		
3) Movement of personnel	-	0.707	1.594	0.812	1.462			0.774	0.605	0.766	1.160	1.165			2.364	2.320	2.354	2.795	3.023		
4) Machinery, handling of tools and supports	7.164	7.067	13.552	7.304	8.043			1.282	2.066	0.833	1.031	1.689			1.773	1.815	1.790	1.945	1.865		
5) Falling objects	0.796	-	6.377	6.493	3.656			0.862	0.958	0.866	1.590	1.106			2.415	2.362	2.638	2.858	3.185		
6) Explosives	-	-	-	-	-			-	-	-	-	-			0.013	0.007	0.019	0.015	0.019		
7) Explosion of firedamp or coal dust	-	-	-	-	-			-	-	-	-	-			0.011	0.016	-	0.002	0.004		
8) Sudden outbursts of firedamp, suffocation by natural gases	-	-	-	-	-			-	-	-	-	-			0.002	0.001	0.003	-	-		
9) Underground combustion and fires	-	-	-	-	-			-	-	-	-	-			0.002	-	-	0.002	-		
10) Inrushes of water	-	-	-	-	-			-	-	-	-	-			-	0.001	-	0.002	-		
11) Electricity	-	-	-	-	-			-	-	-	-	-			0.006	0.007	0.005	0.010	0.021		
12) Other Causes	1.592	3.360	3.189	0.812	-			0.088	0.353	0.700	0.301	0.116			0.289	0.354	0.337	0.341	0.333		
TOTAL	15.124	18.201	31.089	17.043	16.817			7.737	8.291	7.497	8.939	9.375			13.506	13.242	13.246	14.370	15.160		

B. Underground accidents resulting in death within eight weeks

years 1958-69

per '000,000 man-hours

CAUSE	Germany							Belgium						
(1958-1964)	1958	1959	1960	1961	1962	1963	1964	1958	1959	1960	1961	1962	1963	1964
1) Falls of ground	0.268	0.290	0.263	0.216	0.280	0.260	0.200	0.223	0.213	0.299	0.266	0.246	0.264	0.222
2) Haulage and transport	0.179	0.169	0.182	0.196	0.149	0.178	0.300	0.101	0.124	0.157	0.168	0.142	0.245	0.166
3) Movement of personnel	0.094	0.097	0.070	0.086	0.059	0.089	0.071	0.011	0.027	0.008	0.035	0.010	0.057	0.028
4) Machinery, handling of tools and supports	0.010	0.027	0.012	0.027	0.037	0.019	0.028	0.005	0.014	0.016	0.027	0.047	-	0.018
5) Falling objects	0.065	0.041	0.039	0.065	0.094	0.072	0.054	0.016	-	0.008	-	0.010	0.019	0.018
6) Explosives	0.009	0.003	0.003	-	0.004	-	0.002	0.011	0.014	-	-	-	-	-
7) Explosives of firedamp or coal dusts	0.011	0.012	-	-	0.660	0.002	0.002	-	-	0.016	-	-	-	-
8) Sudden outbursts of firedamp, suffocation by natural gases	0.005	0.003	0.002	0.004	0.002	-	-	0.016	0.014	-	-	0.047	-	-
9) Underground combustion and fires	-	0.003	-	0.002	-	0.006	0.009	-	0.007	-	-	-	-	-
10) Inrushes of water	-	0.003	0.002	-	-	0.004	-	0.011	-	-	0.044	0.047	0.019	-
11) Electricity	0.022	0.008	0.002	0.005	0.010	0.002	0.004	0.021	-	0.024	-	-	0.009	0.009
12) Other causes	0.025	0.025	0.036	0.049	0.049	0.025	0.017	0.005	-	0.008	0.009	0.019	0.028	0.009
TOTAL	0.687	0.680	0.611	0.651	1.344	0.657	0.587	0.420	0.413	0.536	0.549	0.568	0.641	0.471
(1965-1969)	1965	1966	1967	1968	1969	1970	1971	1965	1966	1967	1968	1969	1970	1971
1) Falls of ground	0.184	0.197	0.206	0.148	0.192			0.239	0.324	0.264	0.179	0.214		
2) Haulage and transport	0.191	0.175	0.150	0.126	0.143			0.166	0.187	0.180	0.114	0.017		
3) Movement of personnel	0.070	0.094	0.076	0.079	0.056			0.011	0.025	-	0.033	-		
4) Machinery, handling of tools and supports	0.025	0.030	0.020	0.014	0.034			0.052	0.025	0.028	0.065	-		
5) Falling objects	0.058	0.048	0.063	0.051	0.049			-	-	-	0.016	-		
6) Explosives	-	-	-	0.004	-			-	-	-	0.016	-		
7) Explosives of firedamp or coal dust	0.019	0.056	-	0.061	-			0.011	-	-	-	-		
8) Sudden outbursts of firedamp, suffocation by natural gases	0.002	0.002	0.007	-	0.004			0.041	0.013	-	-	-		
9) Underground combustion and fires	0.005	-	-	-	-			0.011	-	-	-	-		
10) Inrushes of water	-	-	-	-	-			-	-	-	-	-		
11) Electricity	0.005	-	0.003	0.004	0.004			0.011	-	0.014	0.033	0.019		
12) Other causes	0.023	0.027	0.017	0.022	0.022			-	0.013	0.042	-	-		
TOTAL	0.582	0.629	0.542	0.509	0.504			0.542	0.587	0.528	0.456	0.330		

CAUSE	France (excl. Provence)							Italy						
(1958-1964)	1958	1959	1960	1961	1962	1963	1964	1958	1959	1960	1961	1962	1963	1964
1) Falls of ground	0.235	0.192	0.186	0.219	0.167	0.120	0.127	0.167	-	0.201	0.225	-	0.366	-
2) Haulage and transport	0.115	0.085	0.082	0.122	0.077	0.121	0.141	-	0.197	-	-	-	-	-
3) Movement of personnel	0.007	0.018	0.027	0.008	0.043	0.009	0.009	-	-	-	-	-	-	-
4) Machinery, handling of tools and supports	0.018	0.040	0.016	0.008	0.030	0.009	0.036	-	-	-	-	-	-	-
5) Falling objects	0.025	0.007	0.004	0.017	0.030	0.009	0.018	-	0.197	-	-	-	-	-
6) Explosives	-	0.026	-	-	-	0.005	0.005	0.501	-	-	-	-	-	-
7) Explosives of firedamp or coal dusts	0.115	0.121	-	-	0.004	-	-	-	-	-	-	-	-	-
8) Sudden outbursts of firedamp, suffocation by natural gases	0.043	0.026	0.019	0.004	-	0.019	0.009	0.167	-	-	-	-	-	-
9) Underground combustion and fires	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10) Inrushes of water	-	-	-	0.004	-	-	-	-	-	-	-	-	-	-
11) Electricity	-	0.011	0.012	-	0.009	0.024	-	-	-	-	-	-	-	-
12) Other causes	0.036	0.029	0.008	-	0.009	0.014	0.014	-	-	-	-	-	-	-
TOTAL	0.594	0.555	0.354	0.382	0.369	0.330	0.359	0.835	0.394	0.201	0.225	-	0.366	-
(1965-1969)	1965	1966	1967	1968	1969	1970	1971	1965	1966	1967	1968	1969	1970	1971
1) Falls of ground	0.164	0.214	0.159	0.177	0.149			-	-	-	-	-		
2) Haulage and transport	0.052	0.126	0.088	0.101	0.186			-	-	0.797	-	-		
3) Movement of personnel	0.042	0.024	0.016	0.025	0.014			-	-	-	-	-		
4) Machinery, handling of tools and supports	0.009	0.015	0.016	0.006	-			-	-	0.797	-	-		
5) Falling objects	0.019	0.015	0.011	0.031	0.014			-	-	-	-	-		
6) Explosives	0.009	0.005	0.005	0.006	-			-	-	-	-	-		
7) Explosives of firedamp or coal dust	0.155	-	-	0.038	-			-	-	-	-	-		
8) Sudden outbursts of firedamp, suffocation by natural gases	-	0.005	0.027	0.019	0.007			-	-	-	-	-		
9) Underground combustion and fires	-	-	-	-	-			-	-	-	-	-		
10) Inrushes of water	0.005	-	0.005	-	-			-	-	-	-	-		
11) Electricity	-	0.010	-	-	0.007			-	-	-	-	-		
12) Other causes	-	0.005	0.005	-	0.007			-	-	-	-	-		
TOTAL	0.455	0.419	0.332	0.403	0.384			-	-	1.594	0	-		

CAUSE	Netherlands							Community						
(1958-1964)	1958	1959	1960	1961	1962	1963	1964	1958	1959	1960	1961	1962	1963	1964
1) Falls of ground	0.262	0.064	0.034	0.114	0.062	0.084	0.043	0.253	0.242	0.235	0.217	0.234	0.217	0.175
2) Haulage and transport	0.077	0.145	0.067	0.095	0.062	0.105	0.172	0.147	0.141	0.146	0.168	0.124	0.167	0.178
3) Movement of personnel	-	-	-	-	-	-	-	0.057	0.063	0.047	0.056	0.045	0.060	0.045
4) Machinery, handling of tools and supports	0.015	0.016	-	-	0.041	-	-	0.011	0.028	0.012	0.021	0.037	0.013	0.030
5) Falling objects	-	0.016	-	-	-	-	0.043	0.045	0.027	0.024	0.041	0.062	0.046	0.037
6) Explosives	-	-	-	-	-	-	-	0.009	0.010	0.002	-	0.002	0.001	0.002
7) Explosives of firedamp or coal dusts	-	-	-	-	-	-	-	0.032	0.036	0.002	-	0.375	0.001	0.001
8) Sudden outbursts of firedamp, suffocation by natural gases	-	-	-	-	-	-	-	0.016	0.010	0.006	0.003	0.007	0.005	0.002
9) Underground combustion and fires	-	-	-	-	-	-	-	-	0.003	-	0.001	-	0.003	0.005
10) Inrushes of water	-	-	-	-	-	-	-	0.002	0.002	0.001	0.006	0.005	0.005	-
11) Electricity	-	-	-	0.019	-	-	-	0.016	0.007	0.007	0.004	0.008	0.008	0.003
12) Other causes	-	-	0.017	-	-	-	-	0.023	0.021	0.024	0.029	0.032	0.021	0.014
TOTAL	0.355	0.241	0.119	0.229	0.166	0.189	0.258	0.610	0.590	0.507	0.546	0.932	0.547	0.492
(1965-1969)	1965	1966	1967	1968	1969	1970	1971	1965	1966	1967	1968	1969	1970	1971
1) Falls of ground	0.044	0.050	0.100	0.172	0.058			0.177	0.208	0.192	0.160	0.176		
2) Haulage and transport	0.177	0.126	-	0.086	-			0.149	0.160	0.128	0.115	0.145		
3) Movement of personnel	-	-	-	-	0.058			0.051	0.060	0.044	0.054	0.038		
4) Machinery, handling of tools and supports	0.022	-	0.067	-	0.117			0.024	0.023	0.024	0.017	0.023		
5) Falling objects	-	-	-	0.043	-			0.037	0.030	0.036	0.040	0.031		
6) Explosives	-	-	-	-	-			0.002	0.001	0.002	0.006	-		
7) Explosives of firedamp or coal dust	-	-	-	-	-			0.053	0.030	-	0.044	-		
8) Sudden outbursts of firedamp, suffocation by natural gases	-	-	-	-	-			0.006	0.004	0.012	0.006	0.004		
9) Underground combustion and fires	-	-	-	-	-			0.005	-	-	-	-		
10) Inrushes of water	-	-	-	-	-			0.001	-	0.002	-	-		
11) Electricity	-	-	-	-	-			0.004	0.003	0.004	0.006	0.006		
12) Other causes	-	-	-	-	-			0.013	0.017	0.015	0.012	0.015		
TOTAL	0.243	0.176	0.167	0.301	0.233			0.522	0.536	0.457	0.460	0.438		

C. Comparative Table of underground group accidents (see (1) below)

years 1960-(9

Germany

CAUSE (1960-1965)	1960			1961			1962			1963			1964			1965		
	N	a	b	N	a	b	N	a	b	N	a	b	N	a	b	N	a	b
1) Falls of ground	2	2	10	-	-	-	1	1	6	-	-	-	-	-	-	-	-	-
2) Haulage and transport	-	-	-	-	-	-	-	-	-	-	-	-	2	5	14	-	-	-
3) Movement of personnel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4) Machinery, handling of tools and supports	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5) Falling objects	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6) Explosives	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7) Explosions of firedamp or coal dust	-	-	-	-	-	-	3	62	338	-	-	-	-	-	-	1	4	8
8) Sudden outbursts of firedamp, suffocation by natural gases	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9) Underground combustion and fires	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10) Inrushes of water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11) Electricity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12) Other causes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	2	2	10	-	-	-	4	63	344	-	-	-	2	5	14	1	4	8
(1966-1969)	1966			1967			1968			1969			1970			1971		
	N	a	b	N	a	b	N	a	b	N	a	b	N	a	b	N	a	b
1) Falls of ground	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2) Haulage and transport	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3) Movement of personnel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4) Machinery, handling of tools and supports	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5) Falling objects	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6) Explosives	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7) Explosions of firedamp or coal dust	2	5	21	-	-	-	1	-	17	-	-	-	-	-	-	-	-	-
8) Sudden outbursts of firedamp, suffocation by natural gases	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9) Underground combustion and fires	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10) Inrushes of water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11) Electricity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12) Other causes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	2	5	21	-	-	-	1	-	17	-	-	-	-	-	-	-	-	-

Belgium

CAUSE (1960-1965)	1960			1961			1962			1963			1964			1965		
	N	a	b	N	a	b	N	a	b	N	a	b	N	a	b	N	a	b
1) Falls of ground	-	-	-	-	-	-	1	2	6	-	-	-	-	-	-	-	-	-
2) Haulage and transport	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3) Movement of personnel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4) Machinery, handling of tools and supports	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5) Falling objects	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6) Explosives	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7) Explosions of firedamp or coal dust	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	33
8) Sudden outbursts of firedamp, suffocation by natural gases	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9) Underground combustion and fires	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10) Inrushes of water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11) Electricity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12) Other causes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	-	-	-	-	-	-	1	2	6	-	-	-	-	-	-	2	-	33
(1966-1969)	1966			1967			1968			1969			1970			1971		
	N	a	b	N	a	b	N	a	b	N	a	b	N	a	b	N	a	b
1) Falls of ground	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2) Haulage and transport	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3) Movement of personnel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4) Machinery, handling of tools and supports	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5) Falling objects	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6) Explosives	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7) Explosions of firedamp or coal dust	1	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8) Sudden outbursts of firedamp, suffocation by natural gases	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9) Underground combustion and fires	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10) Inrushes of water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11) Electricity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12) Other causes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	1	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

France (excl. Provence)

CAUSE (1960-1965)	1960			1961			1962			1963			1964			1965		
	N	a	b	N	a	b	N	a	b	N	a	b	N	a	b	N	a	b
1) Falls of ground	-	-	-	1	-	7	1	-	6	-	-	-	-	-	-	-	-	-
2) Haulage and transport	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3) Movement of personnel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4) Machinery, handling of tools and supports	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5) Falling objects	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6) Explosives	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7) Explosions of firedamp or coal dust	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8) Sudden outbursts of firedamp, suffocation by natural gases	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9) Underground combustion and fires	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10) Inrushes of water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11) Electricity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12) Other causes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	-	-	-	1	-	7	1	-	6	-	-	-	-	-	-	-	-	-
(1966-1969)	1966			1967			1968			1969			1970			1971		
	N	a	b	N	a	b	N	a	b	N	a	b	N	a	b	N	a	b
1) Falls of ground	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2) Haulage and transport	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3) Movement of personnel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4) Machinery, handling of tools and supports	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5) Falling objects	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6) Explosives	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7) Explosions of firedamp or coal dust	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8) Sudden outbursts of firedamp, suffocation by natural gases	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9) Underground combustion and fires	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10) Inrushes of water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11) Electricity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12) Other causes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Italy

CAUSE (1960-1965)	1960			1961			1962			1963			1964			1965		
	N	a	b	N	a	b	N	a	b	N	a	b	N	a	b	N	a	b
1) Falls of ground	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2) Haulage and transport	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3) Movement of personnel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4) Machinery, handling of tools and supports	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5) Falling objects	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6) Explosives	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7) Explosions of firedamp or coal dust	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8) Sudden outbursts of firedamp, suffocation by natural gases	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9) Underground combustion and fires	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10) Inrushes of water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11) Electricity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12) Other causes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(1966-1969)	1966			1967			1968			1969			1970			1971		
	N	a	b	N	a	b	N	a	b	N	a	b	N	a	b	N	a	b
1) Falls of ground	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2) Haulage and transport	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3) Movement of personnel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4) Machinery, handling of tools and supports	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5) Falling objects	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6) Explosives	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7) Explosions of firedamp or coal dust	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8) Sudden outbursts of firedamp, suffocation by natural gases	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9) Underground combustion and fires	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10) Inrushes of water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11) Electricity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12) Other causes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Netherlands

CAUSE (1960-1965)	1960			1961			1962			1963			1964			1965		
	N	a	b	N	a	b	N	a	b	N	a	b	N	a	b	N	a	b
1) Falls of ground	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2) Haulage and transport	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3) Movement of personnel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4) Machinery, handling of tools and supports	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5) Falling objects	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6) Explosives	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7) Explosions of firedamp or coal dust	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8) Sudden outbursts of firedamp, suffocation by natural gases	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9) Underground combustion and fires	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10) Inrushes of water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11) Electricity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12) Other causes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(1966-1969)	1966			1967			1968			1969			1970			1971		
	N	a	b	N	a	b	N	a	b	N	a	b	N	a	b	N	a	b
1) Falls of ground	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2) Haulage and transport	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3) Movement of personnel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4) Machinery, handling of tools and supports	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5) Falling objects	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6) Explosives	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7) Explosions of firedamp or coal dust	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8) Sudden outbursts of firedamp, suffocation by natural gases	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9) Underground combustion and fires	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10) Inrushes of water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11) Electricity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12) Other causes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Community

CAUSE (1960-1965)	1960			1961			1962			1963			1964			1965		
	N	a	b	N	a	b	N	a	b	N	a	b	N	a	b	N	a	b
1) Falls of ground	2	2	10	1	-	7	3	3	18	-	-	-	-	-	-	-	-	-
2) Haulage and transport	-	-	-	-	-	-	-	-	-	-	-	-	2	5	14	-	-	-
3) Movement of personnel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4) Machinery, handling of tools and supports	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5) Falling objects	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6) Explosives	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7) Explosions of firedamp or coal dust	-	-	-	-	-	-	3	62	338	-	-	-	-	-	-	3	4	41
8) Sudden outbursts of firedamp, suffocation by natural gases	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9) Underground combustion and fires	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10) Inrushes of water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11) Electricity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12) Other causes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	2	2	10	1	-	7	6	65	356	-	-	-	2	5	14	3	4	41
(1966-1969)	1966			1967			1968			1969			1970			1971		
	N	a	b	N	a	b	N	a	b	N	a	b	N	a	b	N	a	b
1) Falls of ground	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2) Haulage and transport	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3) Movement of personnel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4) Machinery, handling of tools and supports	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5) Falling objects	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6) Explosives	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7) Explosions of firedamp or coal dust	3	11	21	-	-	-	1	-	17	-	-	-	-	-	-	-	-	-
8) Sudden outbursts of firedamp, suffocation by natural gases	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9) Underground combustion and fires	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10) Inrushes of water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11) Electricity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12) Other causes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	3	11	21	-	-	-	1	-	17	-	-	-	-	-	-	-	-	-

(1) Accidents involving more than five casualities of type (a).
(N) Number of group accidents.
(a) Casualties were unable te resume work below ground for at least eight weeks.
(b) Casualties died within eight weeks.

D. RECAPITULATION: COMMUNITY OVERALL

Year	Extraction (1)	Underground o.m.s. (kg.)	Million man-hours worked	Fatalities	Serious injuries (disablement for 8 weeks or over)	Fatalities per m.tons	Serious injuries per m. tons	Fatalities per m. man-hours	Serious injuries per m. man-hours
1958	252.278	1,634	1.260	770	17,074	3.052	67.68	0.610	13.551
1959	240.602	1,788	1,122	622	14,539	2.585	60.43	0.590	12.950
1960	239.967	1,958	1.037	526	13,459	2.192	56.09	0,507	12,986
1961	235.848	2,100	962	527	12,720	2.235	53.93	0.548	13.227
1962	233.233	2,229	901	840(2) 541(3)	12,418	3.602(2) 2.320(3)	53.24	0.932(2) 0.600(3)	13.781
1963	229.769	2,331	849	465	11,686	2.024	50,86	0.547	13.761
1964	235.007	2,395	841	411	11,726	1.749	49.89	0.493	13.860
1965	224.249	2,461	784	410	10,595	1.828	47.25	0.522	13.506
1966	210.189	2,611	698	374	9,247	1.779	43.99	0.536	13.242
1967	189.484	2,824	587	269	7,781	1.420	41.06	0.457	13.246
1968	181.170	3,065	522	240	7,501	1,326	41.44	0.460	14.370
1969	176.900	3,265	476	209	7,222	1.181	40.82	0.438	15.160
1970									
1971									

(1) Net extraction, slurry and dust.

(2) Incl. Luisenthal explosion.

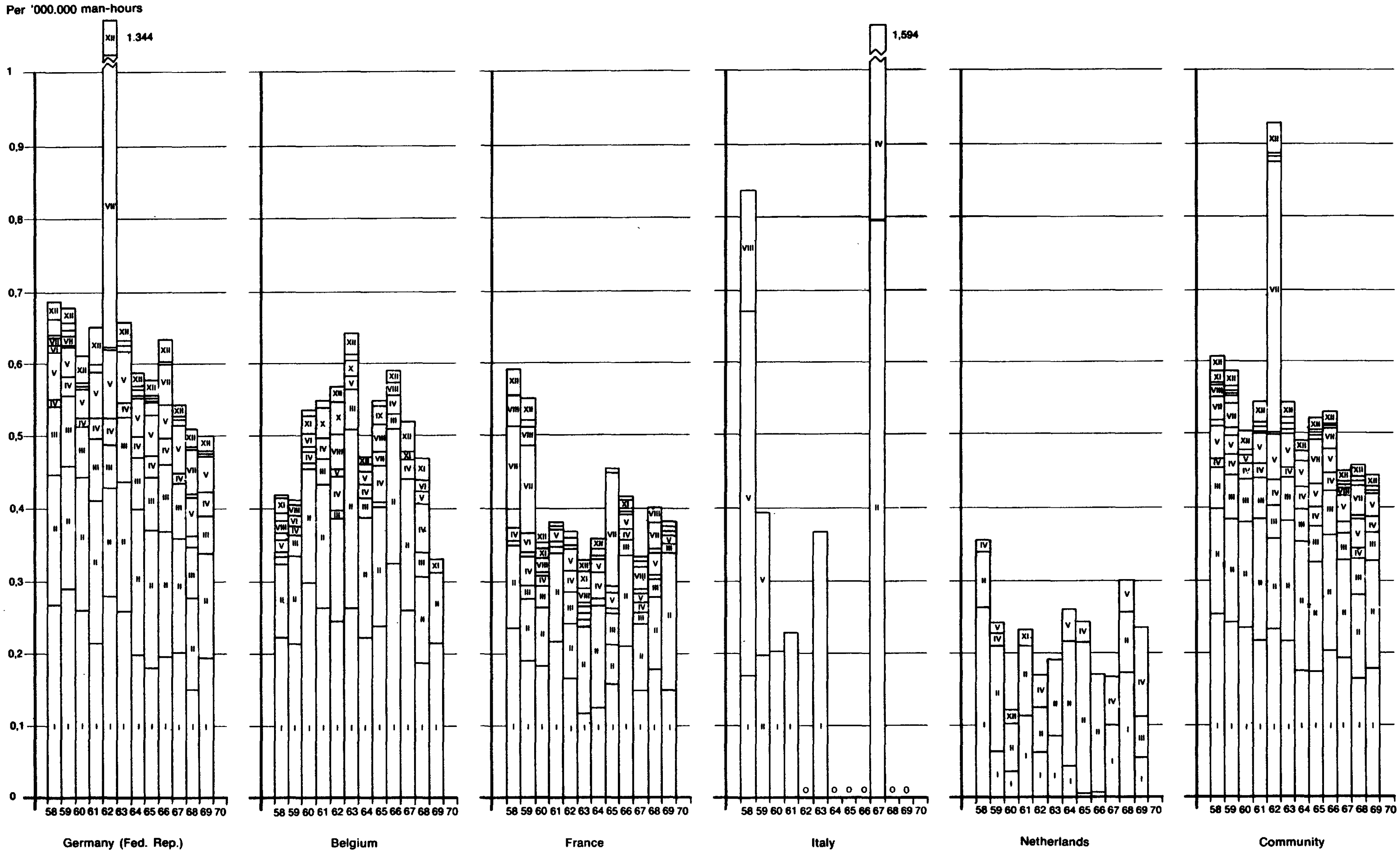
(3) Excl. Luisenthal explosion.

GRAPHS
OF FATAL AND SERIOUS CASUALTIES
IN COMMUNITY COALMINES

KEY
to Roman figures in Graphs

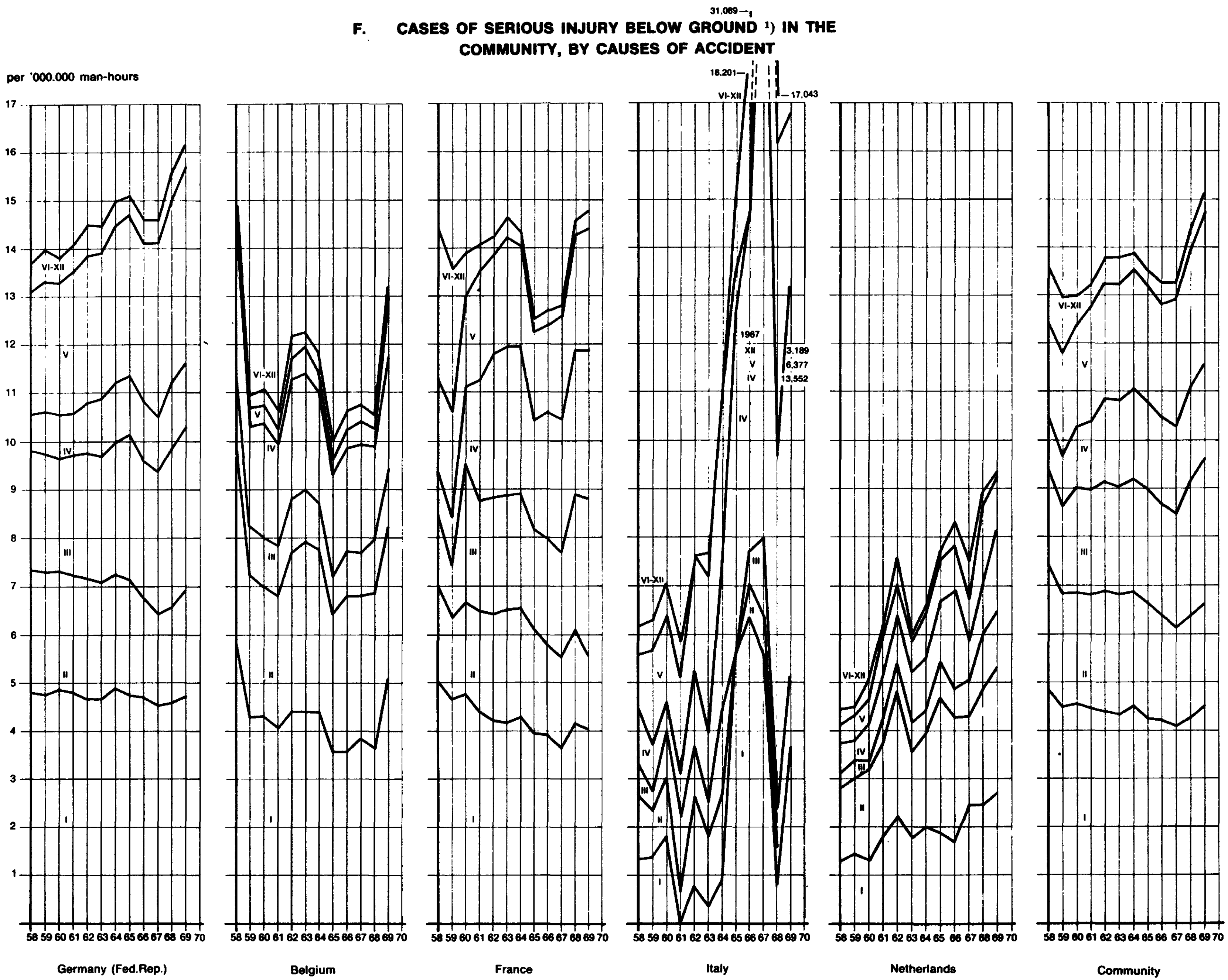
I	Falls of ground
II	Haulage and transport
III	Movement of personnel
IV	Machinery, handling of tools and supports
V	Falling objects
VI	Explosives
VII	Explosions of firedamp or coal dust
VIII	Sudden outbursts of firedamp, suffocation by natural gases
IX	Fires and underground combustion
X	Inrushes of water
XI	Electricity
XII	Other causes

E. FATALITIES BELOW GROUND IN THE COMMUNITY [1]) BY CAUSES OF ACCIDENT



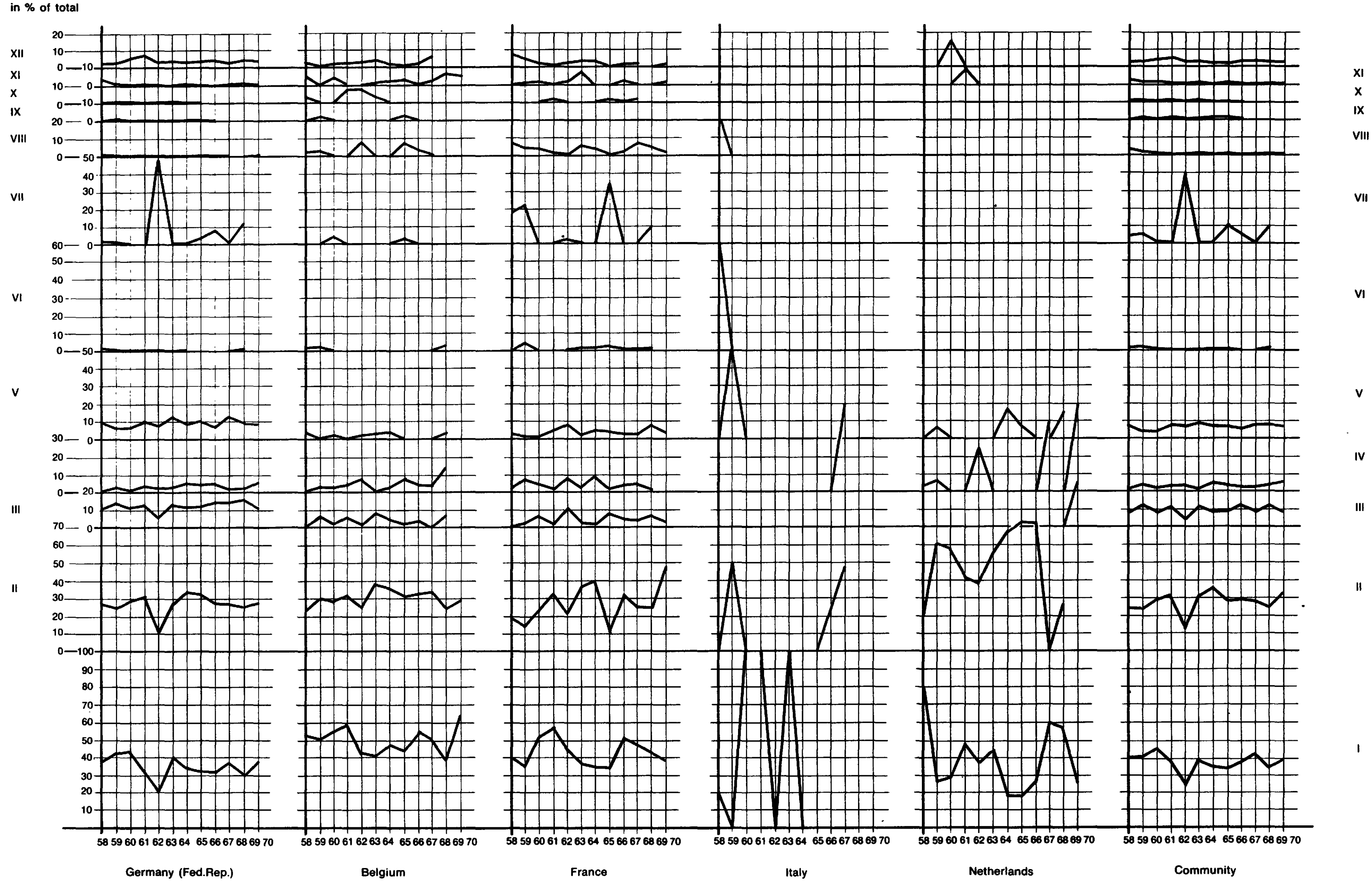
[1]) CASUALTIES DIED WITHIN EIGHT WEEKS

F. CASES OF SERIOUS INJURY BELOW GROUND [1]) IN THE COMMUNITY, BY CAUSES OF ACCIDENT



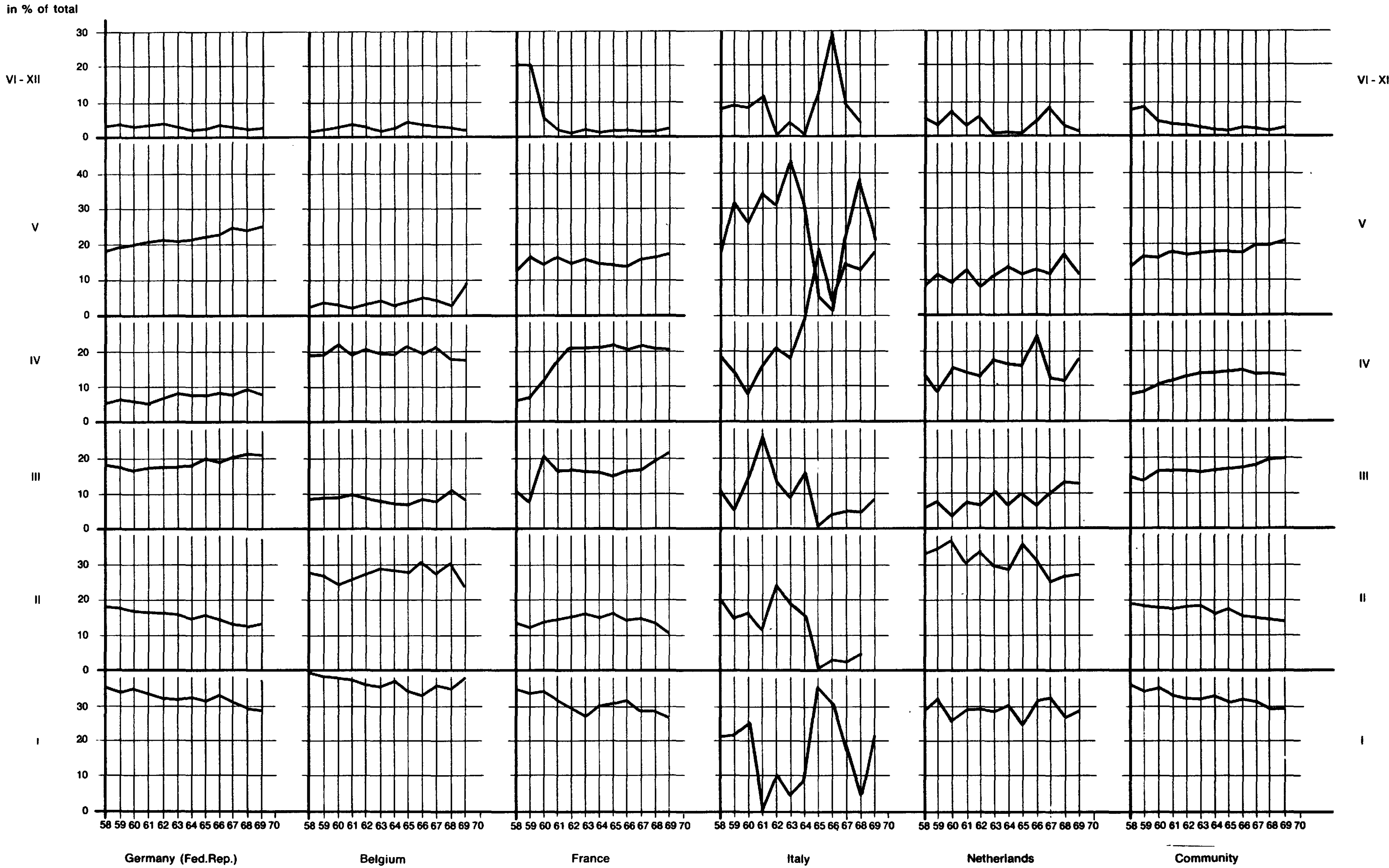
[1]) CASUALTIES WERE UNABLE TO RESUME WORK BELOW GROUND FOR AT LEAST EIGHT WEEKS

G. FATALITIES BELOW GROUND [1]) IN THE COMMUNITY BY CAUSES OF ACCIDENT



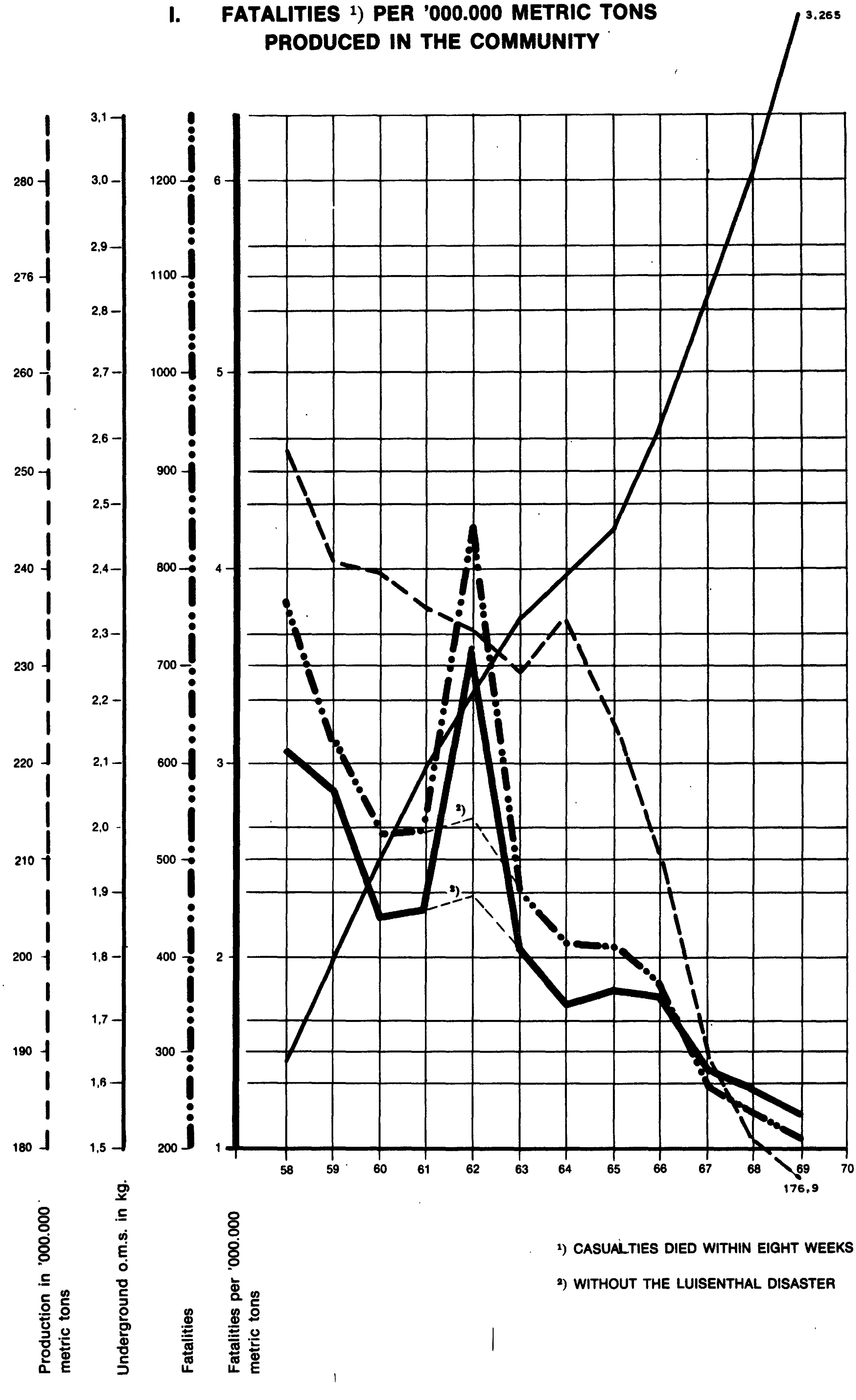
[1]) CASUALTIES DIED WITHIN EIGHT WEEKS

H. CASES OF SERIOUS INJURY BELOW GROUND [1] IN THE COMMUNITY BY CAUSES OF ACCIDENT



[1] CASUALTIES WERE UNABLE TO RESUME WORK BELOW GROUND FOR AT LEAST EIGHT WEEKS

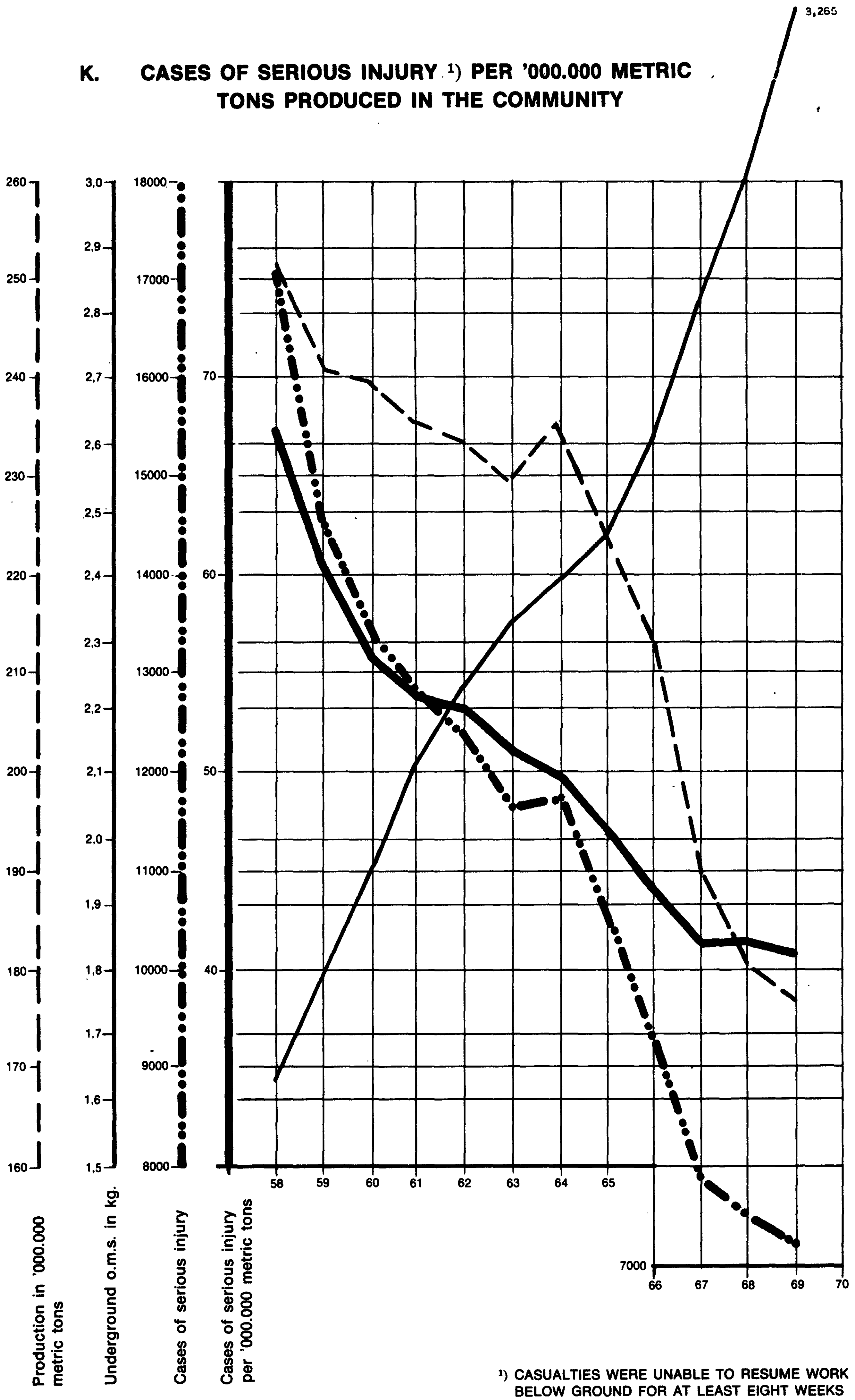
I. FATALITIES 1) PER '000.000 METRIC TONS PRODUCED IN THE COMMUNITY



1) CASUALTIES DIED WITHIN EIGHT WEEKS

2) WITHOUT THE LUISENTHAL DISASTER

K. CASES OF SERIOUS INJURY [1]) PER '000.000 METRIC TONS PRODUCED IN THE COMMUNITY



[1]) CASUALTIES WERE UNABLE TO RESUME WORK BELOW GROUND FOR AT LEAST EIGHT WEEKS

SECTION III

IMPLEMENTATION OF MINES SAFETY AND HEALTH COMMISSION RECOMMENDATIONS

Annex 9 shows the measures taken with regard to the Recommendations, opinions, directives and reports which have been prepared by the Mines Safety and Health Commission since it was set up and transmitted to governments for appropriate action.

The Mines Safety and Health Commission was last informed of these measures in a summary dated 1 January 1968 and published in the Fifth Report.

This Report provides a summary as at 1 January 1970, using a traditional classification.

With regard to the earliest Recommendations, featured in groups A to C, the latter dating back to 1966, an improved degree of implementation of the Recommendations can be noted in 69 instances as compared with the position at 1 January 1968, both in the technical and human factors sphere.

It could be said that implementation is at present at its optimum level, the Recommendations not promulgated as regulations having been reduced to a minimum, which is accounted for by local mining conditions.

With regard to the practical conclusions referred to in group D on the application of the ventilation stabilisation theory, adopted by the Mines Safety and Health Commission in 1968, it should be noted that these are only being put in hand now; the replies received indicate the importance attached to this question by the mining inspectorates in close collaboration with mining concerns.

ANNEXES

ANNEX I

COMMON STATISTICAL SUMMARY OF UNDERGROUND ACCIDENTS AT MINES IN 1969

CONTENTS

1. Common statistical summary of underground accidents at mines in 1969
(Annex I)

2. Terms of reference of the various Working Parties of the Mines Safety and Health Commission
(Annex II)

3. Composition of the Mines Safety and Health Commission and its Working Parties
(Annex III)

4. Seventh Report concerning the organisation of Rescue arrangements for 1967 and 1968
(Annex IV)

5. Report on the characteristics and electrical protection of cables supplying mobile machines (coal-cutters, loading machines etc.) used underground in coal-mines in the various Community countries
(Annex V)

6. Opinion on the use underground of foamed urethane in coal mines
(Annex VI)

7. A new measurement and testing method for ropes used in shafts and roadway-haulage systems and for guides in shaft- and roadway haulage installations
(Annex VII)

8. Report of work in connection with coal-dust neutralisation and anti-explosion barriers
(Annex VIII)

9. Implementation of recommendations of the Mines Safety and Health Commission
(Annex IX)

Year: 1969
Country: Germany
Coal-field: Ruhr (Land North Rhine/ Westphalia)

COMMON STATISTICAL SUMMARY OF UNDERGROUND ACCIDENTS AT MINES IN THE E.C.S.C. COUNTRIES

CAUSE	Number of casualties		Man-hours worked	Number of disablements as under (a) per million man-hours (to third decimal place)	Number of fatalities as under (b) per million man-hours (to third decimal place)	Group accidents as under (c) below		
	Disablements as under (a) below	Fatalities as under (b) below				Number of accidents	Number of disablements as under (a)	Number of fatalities as under (b)
1) Falls of ground	974	35		4,99	0,18	-	-	-
2) Haulage and transport	406	26		2,08	0,13	-	-	-
3) Movement of personnel	716	11		3,67	0,06	-	-	-
4) Machinery, handling of tools and supports	271	9		1,39	0,04	-	-	-
5) Falling objects	804	9		4,12	0,04	-	-	-
6) Explosives and fumes	2	-		0,01	-	-	-	-
7) Explosions of firedamp or coal dust	1	-		0,01	-	-	-	-
8) Sudden outbursts of firedamp, suffocation by natural gases	-	1		-	0,01	-	-	-
9) Underground combustion and fires	-	-		-	-	-	-	-
10) Inrushes of water	-	-		-	-	-	-	-
11) Electricity	6	1		0,03	0,01	-	-	-
12) Other causes	86	4		0,44	0,02	-	-	-
TOTAL	3 266	96	195 050 700	16,74	0,49	-	-	-

(a) Casualties were unable to resume work below ground for at least eight weeks.
(b) Casualties died within eight weeks.
(c) Accidents involving more than five casualties of types (a) and/or (b).

1,3

COMMON STATISTICAL SUMMARY OF UNDERGROUND ACCIDENTS

AT MINES IN THE E.C.S.C. COUNTRIES

Year: 1969
Country: Germany
Coal-field: Aachen (Land North Rhine/Westphalia)

CAUSE	Number of casualties		Man-hours worked	Number of disablements as under (a) per million man-hours (to third decimal place)	Number of fatalities as under (b) per million man-hours (to third decimal place)	Group accidents as under (c) below		
	Disablements as under (a) below	Fatalities as under (b) below				Number of accidents	Number of disablements as under (a)	Number of fatalities as under (b)
1) Falls of ground	152	8		3,56	0,19	-	-	-
2) Haulage and transport	82	5		1,92	0,12	-	-	-
3) Movement of personnel	125	2		2,93	0,05	-	-	-
4) Machinery, handling of tools and supports	44	-		1,03	-	-	-	-
5) Falling objects	115	3		2,70	0,07	-	-	-
6) Explosives and fumes	-	-		-	-	-	-	-
7) Explosions of firedamp or coal dust	-	-		-	-	-	-	-
8) Sudden outbursts of firedamp, suffocation by natural gases	-	-		-	-	-	-	-
9) Underground combustion and fires	-	-		-	-	-	-	-
10) Inrushes of water	-	-		-	-	-	-	-
11) Electricity	1	-		0,02	-	-	-	-
12) Other causes	18	2		0,42	0,04	-	-	-
TOTAL	537	20	42 656 829	12,58	0,47	-	-	-

(a) Casualties were unable to resume work below ground for at least eight weeks.
(b) Casualties died within eight weeks.
(c) Accidents involving more than five casualties of types (a) and/or (b).

Year: 1969
Country: Germany
Coal-field: Saar

COMMON STATISTICAL SUMMARY OF UNDERGROUND ACCIDENTS AT MINES IN THE E.C.S.C. COUNTRIES

CAUSE	Number of casualties		Man-hours worked	Number of disablements as under (a) per million man-hours (to third decimal place)	Number of fatalities as under (b) per million man-hours (to third decimal place)	Group accidents as under (c) below		
	Disablements as under (a) below	Fatalities as under (b) below				Number of accidents	Number of disablements as under (a)	Number of fatalities as under (b)
1) Falls of ground	132	8	27 941 021	4,723	0,286	-	-	-
2) Haulage and transport	95	7	"	3,399	0,250	-	-	-
3) Movement of personnel	62	2	"	2,218	0,072	-	-	-
4) Machinery, handling of tools and supports	28	-	"	1,002	-	-	-	-
5) Falling objects	153	1	"	5,474	0,036	-	-	-
6) Explosives and fumes	-	-	"	-	-	-	-	-
7) Explosions of firedamp or coal dust	-	-	"	-	-	-	-	-
8) Sudden outbursts of firedamp, suffocation by natural gases	-	-	"	-	-	-	-	-
9) Underground combustion and fires	-	-	"	-	-	-	-	-
10) Inrushes of water	-	-	"	-	-	-	-	-
11) Electricity	-	-	"	-	-	-	-	-
12) Other causes	3	-	"	0,107	-	-	-	-
TOTAL	473	18	27 941 021	16,923	0,644	-	-	-

(a) Casualties were unable to resume work below ground for at least eight weeks.
(b) Casualties died within eight weeks.
(c) Accidents involving more than five casualties of types (a) and/or (b).

COMMON STATISTICAL SUMMARY OF UNDERGROUND ACCIDENTS

AT MINES IN THE E.C.S.C. COUNTRIES

Year: 1969
Country: Germany

Coal-field: Total

CAUSE	Number of casualties		Man-hours worked	Number of disablements as under (a) per million man-hours (to third decimal place)	Number of fatalities as under (b) per million man-hours (to third decimal place)	Group accidents as under (c) below		
	Disablements as under (a) below	Fatalities as under (b) below				Number of accidents	Number of disablements as under (a)	Number of fatalities as under (b)
1) Falls of ground	1 258	51	-	4,74	0,19	-	-	-
2) Haulage and transport	583	38	-	2,19	0,14	-	-	-
3) Movement of personnel	903	15	-	3,40	0,06	-	-	-
4) Machinery, handling of tools and supports	343	9	-	1,29	0,04	-	-	-
5) Falling objects	1 072	13	-	4,04	0,05	-	-	-
6) Explosives and fumes	2	-	-	0,01	-	-	-	-
7) Explosions of firedamp or coal dust	1	-	-	•	-	-	-	-
8) Sudden outbursts of firedamp, suffocation by natural gases	-	1	-	-	•	-	-	-
9) Underground combustion and fires	-	-	-	-	-	-	-	-
10) Inrushes of water	-	-	-	-	-	-	-	-
11) Electricity	7	1	-	0,03	•	-	-	-
12) Other causes	107	6	-	0,40	0,02	-	-	-
TOTAL	4 276	134	265 648 850	16,10	0,50	-	-	-

(a) Casualties were unable to resume work below ground for at least eight weeks.
(b) Casualties died within eight weeks.
(c) Accidents involving more than five casualties of types (a) and/or (b).

Year: 1969
Country: Belgium

COMMON STATISTICAL SUMMARY OF UNDERGROUND ACCIDENTS
AT MINES IN THE E.C.S.C. COUNTRIES

Coal-field: Borinage/Centre

CAUSE	Number of casualties		Man-hours worked	Number of disablements as under (a) per million man-hours (to third decimal place)	Number of fatalities as under (b) per million man-hours (to third decimal place)	Group accidents as under (c) below		
	Disablements as under (a) below	Fatalities as under (b) below				Number of accidents	Number of disablements as under (a)	Number of fatalities as under (b)
1) Falls of ground	85	2		16,790	0,395	-	-	-
2) Haulage and transport	29	-		5,728	-	-	-	-
3) Movement of personnel	9	-		1,778	-	-	-	-
4) Machinery, handling of tools and supports	28	-		5,531	-	-	-	-
5) Falling objects	19	-		3,753	-	-	-	-
6) Explosives and fumes	-	-		•	-	-	-	-
7) Explosions of firedamp or coal dust	-	-		-	-	-	-	-
8) Sudden outbursts of firedamp, suffocation by natural gases	-	-		-	-	-	-	-
9) Underground combustion and fires	-	-		-	-	-	-	-
10) Inrushes of water	-	-		-	-	-	-	-
11) Electricity	-	-		-	-	-	-	-
12) Other causes	-	-		-	-	-	-	-
TOTAL	170	2	5 062 640	33,580	0,395	-	-	-

(a) Casualties were unable to resume work below ground for at least eight weeks.
(b) Casualties died within eight weeks.
(c) Accidents involving more than five casualties of types (a) and/or (b).

Year: 1969
Country: Belgium

COMMON STATISTICAL SUMMARY OF UNDERGROUND ACCIDENTS

AT MINES IN THE E.C.S.C. COUNTRIES

Coal-field: Charleroi/Namur

CAUSE	Number of casualties		Man-hours worked	Number of disablements as under (a) per million man-hours (to third decimal place)	Number of fatalities as under (b) per million man-hours (to third decimal place)	Group accidents as under (c) below		
	Disablements as under (a) below	Fatalities as under (b) below				Number of accidents	Number of disablements as under (a)	Number of fatalities as under (b)
1) Falls of ground	67	2		5,873	0,175	-	-	-
2) Haulage and transport	44	3		3,857	0,263	-	-	-
3) Movement of personnel	14	-		1,227	-	-	-	-
4) Machinery, handling of tools and supports	34	-		2,980	-	-	-	-
5) Falling objects	18	-		1,578	-	-	-	-
6) Explosives and fumes	-	-		-	-	-	-	-
7) Explosions of firedamp or coal dust	1	-		0,088	-	-	-	-
8) Sudden outbursts of firedamp, suffocation by natural gases	-	-		-	-	-	-	-
9) Underground combustion and fires	-	-		-	-	-	-	-
10) Inrushes of water	-	-		-	-	-	-	-
11) Electricity	-	-		-	-	-	-	-
12) Other causes	5	-		0,438	-	-	-	-
TOTAL	183	5	11 408 424	16,041	0,438	-	-	-

(a) Casualties were unable to resume work below ground for at least eight weeks.
(b) Casualties died within eight weeks.
(c) Accidents involving more than five casualties of types (a) and/or (b).

Year: 1969
Country: Belgium

COMMON STATISTICAL SUMMARY OF UNDERGROUND ACCIDENTS
AT MINES IN THE E.C.S.C. COUNTRIES

Coal-field: Liège

CAUSE	Number of casualties		Man-hours worked	Number of disablements as under (a) per million man-hours (to third decimal place)	Number of fatalities as under (b) per million man-hours (to third decimal place)	Group accidents as under (c) below		
	Disablements as under (a) below	Fatalities as under (b) below				Number of accidents	Number of disablements as under (a)	Number of fatalities as under (b)
1) Falls of ground	33	4		4,357	0,528	-	-	-
2) Haulage and transport	39	-		5,149	-	-	-	-
3) Movement of personnel	16	-		2,112	-	-	-	-
4) Machinery, handling of tools and supports	17	-		2,244	-	-	-	-
5) Falling objects	5	-		0,660	-	-	-	-
6) Explosives and fumes	-	-		-	-	-	-	-
7) Explosions of firedamp or coal dust	-	-		-	-	-	-	-
8) Sudden outbursts of firedamp, suffocation by natural gases	-	-		-	-	-	-	-
9) Underground combustion and fires	-	-		-	-	-	-	-
10) Inrushes of water	-	-		-	-	-	-	-
11) Electricity	1	1		0,132	0,132	-	-	-
12) Other causes	2	-		0,264	-	-	-	-
TOTAL	113	5	7 574 888	14,918	0,660	-	-	-

(a) Casualties were unable to resume work below ground for at least eight weeks.
(b) Casualties died within eight weeks.
(c) Accidents involving more than five casualties of types (a) and/or (b).

COMMON STATISTICAL SUMMARY OF UNDERGROUND ACCIDENTS

AT MINES IN THE E.C.S.C. COUNTRIES

Year: 1969
Country: Belgium
Coal-field: Campine

CAUSE	Number of casualties: Disablements as under (a) below	Number of casualties: Fatalities as under (b) below	Man-hours worked	Number of disablements as under (a) per million man-hours (to third decimal place)	Number of fatalities as under (b) per million man-hours (to third decimal place)	Group accidents as under (c) below: Number of accidents	Group accidents as under (c) below: Number of disablements as under (a)	Group accidents as under (c) below: Number of fatalities as under (b)
1) Falls of ground	76	3		2,775	0,110	-	-	-
2) Haulage and transport	51	2		1,862	0,073	-	-	-
3) Movement of personnel	22	-		0,803	-	-	-	-
4) Machinery, handling of tools and supports	42	-		1,534	-	-	-	-
5) Falling objects	22	-		0,803	-	-	-	-
6) Explosives and fumes	-	-		-	-	-	-	-
7) Explosions of firedamp or coal dust	-	-		-	-	-	-	-
8) Sudden outbursts of firedamp, suffocation by natural gases	-	-		-	-	-	-	-
9) Underground combustion and fires	-	-		-	-	-	-	-
10) Inrushes of water	-	-		-	-	-	-	-
11) Electricity	-	-		-	-	-	-	-
12) Other causes	2	-		0,073	-	-	-	-
TOTAL	215	5	27 386 128	7,850	0,183	-	-	-

(a) Casualties were unable to resume work below ground for at least eight weeks.
(b) Casualties died within eight weeks.
(c) Accidents involving more than five casualties of types (a) and/or (b).

Year: 1969
Country: Belgium
Coal-field: Total

COMMON STATISTICAL SUMMARY OF UNDERGROUND ACCIDENTS
AT MINES IN THE E.C.S.C. COUNTRIES

CAUSE	Number of casualties		Man-hours worked	Number of disablements as under (a) per million man-hours (to third decimal place)	Number of fatalities as under (b) per million man-hours (to third decimal place)	Group accidents as under (c) below		
	Disablements as under (a) below	Fatalities as under (b) below				Number of accidents	Number of disablements as under (a)	Number of fatalities as under (b)
1) Falls of ground	261	11		5,075	0,214	-	-	-
2) Haulage and transport	163	5		3,169	0,097	-	-	-
3) Movement of personnel	61	-		1,186	-	-	-	-
4) Machinery, handling of tools and supports	121	-		2,353	-	-	-	-
5) Falling objects	64	-		1,244	-	-	-	-
6) Explosives and fumes	-	-		-	-	-	-	-
7) Explosions of firedamp or coal dust	1	-		0,019	-	-	-	-
8) Sudden outbursts of firedamp, suffocation by natural gases	-	-		-	-	-	-	-
9) Underground combustion and fires	-	-		-	-	-	-	-
10) Inrushes of water	-	-		-	-	-	-	-
11) Electricity	1	1		0,019	0,019	-	-	-
12) Other causes	9	-		0,175	-	-	-	-
TOTAL	681	17	51 432 080	13,240	0,330	-	-	-

(a) Casualties were unable to resume work below ground for at least eight weeks.
(b) Casualties died within eight weeks.
(c) Accidents involving more than five casualties of types (a) and/or (b).

Year: 1969
Country: France

COMMON STATISTICAL SUMMARY OF UNDERGROUND ACCIDENTS
AT MINES IN THE E.C.S.C. COUNTRIES

Coal-field: Nord/Pas-de-Calais

CAUSE	Number of casualties		Man-hours worked	Number of disablements as under (a) per million man-hours (to third decimal place)	Number of fatalities as under (b) per million man-hours (to third decimal place)	Group accidents as under (c) below		
	Disablements as under (a) below	Fatalities as under (b) below				Number of accidents	Number of disablements as under (a)	Number of fatalities as under (b)
1) Falls of ground	341	14		4,057	0,166	-	-	-
2) Haulage and transport	93	18		1,106	0,214	-	-	-
3) Movement of personnel	203	-		2,415	-	-	-	-
4) Machinery, handling of tools and supports	207	-		2,462	-	-	-	-
5) Falling objects	184	-		2,189	-	-	-	-
6) Explosives and fumes	1	-		0,012	-	-	-	-
7) Explosions of firedamp or coal dust	-	-		-	-	-	-	-
8) Sudden outbursts of firedamp, suffocation by natural gases	-	1		-	0,012	-	-	-
9) Underground combustion and fires	-	-		-	-	-	-	-
10) Inrushes of water	-	-		-	-	-	-	-
11) Electricity	-	1		-	0,012	-	-	-
12) Other causes	29	-		0,345	-	-	-	-
TOTAL	1 058	34	84 059 136	12,586	0,404	-	-	-

(a) Casualties were unable to resume work below ground for at least eight weeks.
(b) Casualties died within eight weeks.
(c) Accidents involving more than five casualties of types (a) and/or (b).

Year: 1969
Country: France
Coal-field: Lorraine

COMMON STATISTICAL SUMMARY OF UNDERGROUND ACCIDENTS AT MINES IN THE E.C.S.C. COUNTRIES

CAUSE	Number of casualties		Man-hours worked	Number of disablements as under (a) per million man-hours (to third decimal place)	Number of fatalities as under (b) per million man-hours (to third decimal place)	Group accidents as under (c) below		
	Disablements as under (a) below	Fatalities as under (b) below				Number of accidents	Number of disablements as under (a)	Number of fatalities as under (b)
1) Falls of ground	121	6		4,020	0,200	-	-	-
2) Haulage and transport	67	3		2,226	0,099	-	-	-
3) Movement of personnel	165	1		5,482	0,033	-	-	-
4) Machinery, handling of tools and supports	59	-		1,960	-	-	-	-
5) Falling objects	84	1		2,791	0,033	-	-	-
6) Explosives and fumes	1	-		0,033	-	-	-	-
7) Explosions of firedamp or coal dust	-	-		-	-	-	-	-
8) Sudden outbursts of firedamp, suffocation by natural gases	-	-		-	-	-	-	-
9) Underground combustion and fires	-	-		-	-	-	-	-
10) Inrushes of water	-	-		-	-	-	-	-
11) Electricity	-	-		-	-	-	-	-
12) Other causes	1	-		0,033	-	-	-	-
TOTAL	498	11	30 100 040	16,545	0,365	-	-	-

(a) Casualties were unable to resume work below ground for at least eight weeks.
(b) Casualties died within eight weeks.
(c) Accidents involving more than five casualties of types (a) and/or (b).

COMMON STATISTICAL SUMMARY OF UNDERGROUND ACCIDENTS

AT MINES IN THE E.C.S.C. COUNTRIES

Year: 1969
Country: France
Coal-field: Centre-Midi (excl. Provence)

CAUSE	Number of casualties		Man-hours worked	Number of disablements as under (a) per million man-hours (to third decimal place)	Number of fatalities as under (b) per million man-hours (to third decimal place)	Group accidents as under (c) below		
	Disablements as under (a) below	Fatalities as under (b) below				Number of accidents	Number of disablements as under (a)	Number of fatalities as under (b)
1) Falls of ground	107	1		4,029	0,038	-	-	-
2) Haulage and transport	59	5		2,221	0,187	-	-	-
3) Movement of personnel	86	1		3,237	0,038	-	-	-
4) Machinery, handling of tools and supports	166	-		6,249	-	-	-	-
5) Falling objects	89	1		3,350	0,038	-	-	-
6) Explosives and fumes	5	-		0,188	-	-	-	-
7) Explosions of firedamp or coal dust	-	-		-	-	-	-	-
8) Sudden outbursts of firedamp, suffocation by natural gases	-	-		-	-	-	-	-
9) Underground combustion and fires	-	-		-	-	-	-	-
10) Inrushes of water	-	-		-	-	-	-	-
11) Electricity	2	-		0,075	-	-	-	-
12) Other causes	11	1		0,414	0,038	-	-	-
TOTAL	525	9	26 564 176	19,763	0,339	-	-	-

(a) Casualties were unable to resume work below ground for at least eight weeks.
(b) Casualties died within eight weeks.
(c) Accidents involving more than five casualties of types (a) and/or (b).

Year: 1969
Country: France

COMMON STATISTICAL SUMMARY OF UNDERGROUND ACCIDENTS
AT MINES IN THE E.C.S.C. COUNTRIES

Coal-field: Total (excl. Provence)

CAUSE	Number of casualties		Man-hours worked	Number of disablements as under (a) per million man-hours (to third decimal place)	Number of fatalities as under (b) per million man-hours (to third decimal place)	Group accidents as under (c) below		
	Disablements as under (a) below	Fatalities as under (b) below				Number of accidents	Number of disablements as under (a)	Number of fatalities as under (b)
1) Falls of ground	569	21		4,044	0,149	-	-	-
2) Haulage and transport	219	26		1,556	0,186	-	-	-
3) Movement of personnel	454	2		3,226	0,014	-	-	-
4) Machinery, handling of tools and supports	432	-		3,070	-	-	-	-
5) Falling objects	357	2		2,537	0,014	-	-	-
6) Explosives and fumes	7	-		0,050	-	-	-	-
7) Explosions of firedamp or coal dust	-	-		-	-	-	-	-
8) Sudden outbursts of firedamp, suffocation by natural gases	-	1		-	0,007	-	-	-
9) Underground combustion and fires	-	-		-	-	-	-	-
10) Inrushes of water	-	-		-	-	-	-	-
11) Electricity	2	1		0,014	0,007	-	-	-
12) Other causes	41	1		0,291	0,007	-	-	-
TOTAL	2 081	54	140 723 352	14,788	0,384	-	-	-

(a) Casualties were unable to resume work below ground for at least eight weeks.
(b) Casualties died within eight weeks.
(c) Accidents involving more than five casualties of types (a) and/or (b).

Year: 1969
Country: Italy
Coal-field: Sulcis

COMMON STATISTICAL SUMMARY OF UNDERGROUND ACCIDENTS AT MINES IN THE E.C.S.C. COUNTRIES

CAUSE	Number of casualties		Man-hours worked	Number of disablements as under (a) per million man-hours (to third decimal place)	Number of fatalities as under (b) per million man-hours (to third decimal place)	Group accidents as under (c) below		
	Disablements as under (a) below	Fatalities as under (b) below				Number of accidents	Number of disablements as under (a)	Number of fatalities as under (b)
1) Falls of ground	5	-		3,656	-	-	-	-
2) Haulage and transport	-	-		-	-	-	-	-
3) Movement of personnel	2	-		1,462	-	-	-	-
4) Machinery, handling of tools and supports	11	-		8,043	-	-	-	-
5) Falling objects	5	-		3,656	-	-	-	-
6) Explosives and fumes	-	-		-	-	-	-	-
7) Explosions of firedamp or coal dust	-	-		-	-	-	-	-
8) Sudden outbursts of firedamp, suffocation by natural gases	-	-		-	-	-	-	-
9) Underground combustion and fires	-	-		-	-	-	-	-
10) Inrushes of water	-	-		-	-	-	-	-
11) Electricity	-	-		-	-	-	-	-
12) Other causes	-	-		-	-	-	-	-
TOTAL	23	-	1 367 618	16,817	-	-	-	-

(a) Casualties were unable to resume work below ground for at least eight weeks.
(b) Casualties died within eight weeks.
(c) Accidents involving more than five casualties of types (a) and/or (b).

Year: 1969
Country: Netherlands
Coal-field: Limburg

COMMON STATISTICAL SUMMARY OF UNDERGROUND ACCIDENTS AT MINES IN THE E.C.S.C. COUNTRIES

CAUSE	Number of casualties		Man-hours worked	Number of disablements as under (a) per million man-hours (to third decimal place)	Number of fatalities as under (b) per million man-hours (to third decimal place)	Group accidents as under (c) below		
	Disablements as under (a) below	Fatalities as under (b) below				Number of accidents	Number of disablements as under (a)	Number of fatalities as under (b)
1) Falls of ground	47	1		2,737	0,058	-	-	-
2) Haulage and transport	44	-		2,562	-	-	-	-
3) Movement of personnel	20	1		1,165	0,058	-	-	-
4) Machinery, handling of tools and supports	29	2		1,689	0,117	-	-	-
5) Falling objects	19	-		1,106	-	-	-	-
6) Explosives and fumes	-	-		-	-	-	-	-
7) Explosions of firedamp or coal dust	-	-		-	-	-	-	-
8) Sudden outbursts of firedamp, suffocation by natural gases	-	-		-	-	-	-	-
9) Underground combustion and fires	-	-		-	-	-	-	-
10) Inrushes of water	-	-		-	-	-	-	-
11) Electricity	-	-		-	-	-	-	-
12) Other causes	2	-		0,116	-	-	-	-
TOTAL	161	4	17 173 976	9,375	0,233	-	-	-

(a) Casualties were unable to resume work below ground for at least eight weeks.
(b) Casualties died within eight weeks.
(c) Accidents involving more than five casualties of types (a) and/or (b).

Comparative table of number of persons
incapacitated by underground accidents for eight weeks or longer
in 1969
per million man-hours

C A U S E	Germany	Belgium	France (1)	Italy	Netherlands	Community
1) Falls of ground	4.736	5.075	4.044	3.656	2.737	4.492
2) Haulage and transport	2.195	3.169	1.556	-	2.562	2.118
3) Movement of personnel	3.399	1.186	3.226	1.462	1.165	3.023
4) Machinery, handling of tools and supports	1.291	2.353	3.070	8.043	1.689	1.965
5) Falling objects	4.036	1.244	2.537	3.656	1.106	3.185
6) Explosives and fumes	0.007	-	0.050	-	-	0.019
7) Explosions of firedamp, or coal dust	0.004	0.019	-	-	-	0.004
8) Sudden outbursts of firedamp suffocation by natural gases	-	-	-	-	-	-
9) Underground combustion and fires	-	-	-	-	-	-
10) Inrushes of water	-	-	-	-	-	-
11) Electricity	0.026	0.019	0.014	-	-	0.021
12) Other causes	0.402	0.175	0.291	-	0.116	0.333
TOTAL	16.096	13.240	14.788	16.817	9.375	15.160

(1) Excluding Provence.

Comparative table of accidents
resulting in death within eight weeks
in 1969
per million man-hours

CAUSE	Germany	Belgium	France (1)	Italy	Netherlands	Community
1) Falls of ground	0.192	0.214	0.149	-	0.058	0.176
2) Haulage and transport	0.143	0.097	0.186	-	-	0.145
3) Movement of personnel	0.056	-	0.014	-	0.058	0.038
4) Machinery, handling of tools and supports	0.034	-	-	-	0.117	0.023
5) Falling objects	0.049	-	0.014	-	-	0.031
6) Explosives and fumes	-	-	-	-	-	-
7) Explosions of firedamp, or coal dust	-	-	-	-	-	-
8) Sudden outbursts of firedamp, suffocation by natural gases	0.004	-	0.007	-	-	0.004
9) Underground combustion and fires	-	-	-	-	-	-
10) Inrushes of water	-	-	-	-	-	-
11) Electricity	0.004	0.019	0.007	-	-	0.006
12) Other causes	0.022	-	0.007	-	-	0.015
TOTAL	0.504	0.330	0.384	-	0.233	0.438

(1) Excluding Provence.

ANNEX II

TERMS OF REFERENCE OF THE VARIOUS WORKING PARTIES OF THE MINES SAFETY AND HEALTH COMMISSION

I. Working Party on Electrification - Chairman Mr. LOGELAIN

A. Terms of reference

1. Comparing adopted safety and accident prevention provisions relating to:

   a) electric shock,

   b) fire hazard,

   c) explosion hazard.

2. Ascertaining the present position in Community countries with regard to safety regulations on underground electrical networks of low and medium voltage (up to 1,100 V) and feeder cables for movable equipment, with due regard to the specifications for the said cables.

3. Reporting on steps to be taken when work has to be carried out on electrical equipment under voltage.

4. Studying the deleterious effects on electrical equipment used underground of moisture in salt pastes and salt pastes used in dust suppression.

5. Studying the construction of high-tension cables (of up to 6,000 V) used underground, and protective equipment.

6. Comparison of safety provisions relating to underground electric locomotives, with emphasis on the possibility of reducing the frequency of trolley wire sparking.

7. Study of over-voltage caused by lightning and the problem of stray currents.

B. Preliminary work undertaken by the Secretariat

1. Periodic reports on oil-powered contactors used in gassy environments.

2. Investigations of the use of remote-control circuits in automated mining operations.

II. Working Party on Rescue Arrangements, Fires and Underground Combustion - Chairman Mr. HELLER

A. Rescue Arrangements, Fires and Underground Combustion

General Terms of reference (Section 7 of the Mines Safety and Health Commission's Terms of Reference)

Exchange of information on rescue work and fire-fighting in connection with accidents of interest to the Working Party.

B. Rescue work

I. Standing terms of reference

1. Communication of the annual reports issued by the rescue stations and regular discussion of these documents.

2. Convening meetings on special occasions (accidents from which new information can be gained, technical innovations in materials, equipment, etc.).

3. The publication every two years of a report outlining in particular the state of rescue arrangements in the Community and the United Kingdom.

II. Terms of reference

1. Improvements in respirators used by rescue workers.

2. Improvements in CO-filter self-rescuers.

3. Drawing up a list of experts on drillings in connection with rescue work and the apparatus to be used.

4. Examination of the technique for rescuing trapped miners by means of large boreholes with a view to formulating the rules based on experience gained in different countries and submitting practical regulations to the mining authorities.

5. Studying of the Community criteria for fireproof clothing and general requirements.

6. Examination of the need to draw up, alongside traditional alarm procedures, plans for sending help in the event of disaster.

7. Drawing up a synoptic comparison of the rules and regulations relating to rescue and medical attention as drafted by the mining authorities of the Community and of the United Kingdom.

C. Underground fires

I. Standing terms of reference

Exchanging views on the reopening in the Community and the United Kingdom of fire zone stoppings and where necessary adapting regulations already drafted.

II. Terms of reference

1. Continuing the study of the problem of sealing off fire and ventilation stoppings as well as roadway walls, by means of urethane foam. Examining this question so that, if appropriate, suitable proposals may be submitted to the Mines Safety and Health Commission.

2. Continuing the study of the problem of fire-fighting in very deep pits, if necessary with the help of small-scale model tests and full-scale experiments, should a favourable opportunity arise.

3. Continued study of specifications and test conditions applicable to fire resistant fluids (3.a)-c) by the experts on hydraulic fluids):

   a) comparing test results so as to prevent products being differently assessed;

   b) where necessary, adapting test criteria to technological progress;

   c) in addition, examining to what extent it might be possible to relax these criteria and test methods so that the said products may be more easily assessed and approved.

4. Continued study of the stabilisation of ventilation in the event of pit fires in accordance with Professor Budryk's theory (4.a)-h) by the ventilation experts):

   - Problems outstanding within the framework of the former terms of reference:

   a) the extent of instability in diagonal ventilation roadways,

   b) the effects of a fire on descensional ventilation systems,

   c) means of guarding against the danger of explosion during fire-fighting.

- Extension of this term of reference to general ventilation problems in view of their importance, especially to fires:

d) assessment of the danger of explosion in a fire area during its isolation by means of stoppings,

e) effects of auxiliary ventilators on pit ventilation in the event of fire,

f) ventilation tolerances (where the object is to study problems of stability: measurement of wind speeds, air flow and pressures),

g) possibilities of early detection and technical measurement of parasitic air currents,

h) use of fire regulators and fire doors.

5. Early detection of underground fires, especially smouldering fires, and assessment of combustible gases (remote control installations for the early detection of CO).

6. Measuring instruments enabling ventilation to be checked (oxygen deficiency warning devices): Exchange of information on the practical use of oxygen deficiency warning devices, especially those which were singled out for special mention in the competition organised by the High Authority (concluded in December 1967).

7. Sealing off abandoned underground workings by means of dams.

8. Generation of fire in means of transport and other long installations (conveyor belts, air ducts, piping, guides, etc.) and propagation of fire by means of these installations.

9. Synoptic comparison of rules and regulations on fire prevention and fire-fighting in mines, worked out by the mining authorities of member countries and of the United Kingdom.

III. Working Party on Winding Ropes and Shaft Guides - Chairman Mr. MARTENS

Terms of reference

1. Follow-up of progress made in the electro-magnetic testing of winding ropes so as to obtain information on their use in Community mines.

2. Testing of couplings for circular and flattened winding ropes.

3. Arrangements for the installation of capels.

4. Control of shaft guides by means of automatic decelerometers.

5. Maintenance required to ensure safe operation of winding ropes and balance ropes.

IV. Working Party on Mining Accident Statistics - Chairman Mr. KOCH

Terms of reference

Examination of the methods used in Community countries for establishing mining accident statistics. Particular examination of the criteria applied in defining the term "Mining accident" and the criteria used in classifying the accidents according to cause, duration of stoppage and, possibly, position of the injuries.

With the exact definition of these criteria as a basis, establishing differences between the statistical elements assembled in each country and ways of taking these differences into account in comparisons on a Community level.

V. <u>Working Party on Combustible Dusts - Chairman Mr. CHERADAME</u>

The detailed terms of reference given by the Mines Safety and Health Commission to this Working Party are as follows:

To carry out a study of precautions against dust combustion, particularly:

- <u>dust neutralisation</u> (dust control in situ, stone-dusting, spraying, dust fixation by spreading salts and coagulating pastes, etc.),
- <u>dust barriers</u> (different types of dust barriers, their construction, siting, etc.),

taking into account:

a) the mechanism of dust combustion and of flame propagation

b) factors, such as these listed below, which may affect ignition and the propagation of the dust explosion:

nature of the coal and/or the volatile matter content
fineness of the coal
concentration of dust
methane content
cause of ignition
effect of moisture
geometrical features of the roadway.

The Working Party may make any suggestions for research work considered necessary to advance the knowledge of the phenomena studied and to promote safety in these fields.

In its meeting of 10.10.1968 the Mines Safety and Health Commission clarified and extended certain items in the terms of reference, as follows:

1. The Working Party must take account of the fact that methane is frequently involved in explosions. In particular:

   a) the "aide-mémoire" to investigators shall be extended to methane explosions and reports thereon shall be distributed in the same way as reports on accidents due to dust explosions;

   b) the study of the mechanism of the initiation and propagation of the explosions and the factors affecting them, as set out in the terms of reference, shall take into account the involvement of methane in the phenomenon;

   c) with regard to dust barriers, to halt dust explosions, mixed dust/methane explosions and pure methane explosions, the Secretariat shall follow up the results of tests in hand and, at the proper time, assemble for the use of the Working Party the information required to work out a practical draft recommendation.

2. The study of the neutralisation of dusts shall include:

   the comparative analysis of the regulations and instructions applied in the Community countries and in the United Kingdom;

   the various methods of application: the nature of the substance, frequency of spreading, frequency of inspection, and the detailed justification of the sampling method used.

VI. <u>Working Party on Health in Coal Mines - Chairman Mr. VANDENHEUVEL</u>

Studying, from the standpoint of technical prevention and industrial medicine, <u>the prevention of environmental risks</u> to the health of workers in coal mines.

A. Terms of reference

1. Where necessary, making recommendations on means of dust control, and general measures to reduce dustiness in underground workings, recognised as being to some extent effective (wet drilling, water infusion, spraying, special attachments to winning machines, pulsed-infusion shotfiring, etc.);

2. Where necessary, making recommendations on the organisation of specialised dust-control services.

B. Preliminary work to be undertaken by the Secretariat

The assembling of documentary material and comparison of legislation in the various Community countries with reference to:

1. General rules covering the prevention of dust in respect of the design and use of winning machines.

   Standards to be observed to ensure minimum dustiness arising from the use of these machines.

2. Dust measurement (methods, frequency, measuring points, conclusions to be drawn etc.) and where necessary establishing a scale of comparison of the various methods employed.

3. Establishment of dustiness thresholds. Definition of categories of permissible dustiness. Steps to be taken when faced with various categories of dustiness.

VII. Working Party on Effects of Working Time on Safety at Work, especially in Difficult or Unhealthy Conditions - Chairman Mr. VAN DER HOOFT

Provisional terms of reference (definitive text to be submitted to the Restricted Committee):

Number of hours worked in wet working points. Determining in what cases a working point is to be considered wet and the precautions to be taken.

VIII. Working Party on Psychological and Sociological Factors affecting Safety - Chairman Mr. SCHNASE

Terms of reference

1. Safety campaigns.

2. A draft recommendation on the employment of foreign and young workers.

ANNEX III

COMPOSITION OF THE MINES SAFETY AND HEALTH COMMISSION AND ITS WORKING PARTIES (AS AT 31.12.1969)

A.- MINES SAFETY AND HEALTH COMMISSION

FEDERAL REPUBLIC OF GERMANY

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J. OLYSIAEGERS, Secrétaire national de la Centrale syndicale des travailleurs des mines de Belgique, F.G.T.B., Koolmijnlaan 1, Houthalen

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Dott. Consigliere B. COLUCCI, Direzione generale dell'emigrazione, Ministero degli affari esteri, Roma

Dott. Ing. M. MARRA, Ispettore generale delle miniere, Ministero dell'industria e commercio, via Veneto 33, Roma

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Prof. M. CARTA, Istituto Arte Mineraria della facoltà d'Ingegneria, Piazza d'Armi, Cagliari (Sardegna)

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Dott. C. MICHELAZZI, Ispettore generale del Ministero del lavoro e della previdenza sociale, via Flavia 6, Roma

Dott. R. PURPURA, Direttore generale al Ministero del lavoro, via Flavia 6, Roma

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Employers' Representative

Dr. H.L. WILLET, Deputy Director-General of Production, National Coal Board, Hobart House, Grosvenor Place, London S.W.1

Workers' Representative

S. BULLOUGH, Vice-President of the National Union of Mineworkers, c/o Miners' Offices, Barnsley / Yorkshire

INTERNATIONAL LABOUR ORGANISATION, GENEVA

A representative of the International Labour Office sitting as an observer.

B.- RESTRICTED COMMITTEE

The Restricted Committee consists of the Government members of the Mines Safety and Health Commission.

C.- WORKING PARTIES ON TECHNICAL QUESTIONS

I. Working Party on Electrification

- Members of the Working Party

GERMANY

Oberbergrat W. SCHÖTTELNDREIER, Oberbergamt, 46 Dortmund, Goebenstr. 25

Dipl. Ing. L. GEBHARDT, Steinkohlenbergbauverein, 43 Essen

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G.J.A. COOLS, Divisiedirecteur van het Mijnwezen, 24-26, rue J.A. Demot, Bruxelles 4

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P. FLINOIS, Houillères du bassin du Nord et du Pas-de-Calais, service technique du fond, 20, rue des Minimes, Douai/Nord

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(1) Chairman of the Working Party as representative of the Restricted Committee

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- Experts on cables and leads

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H. GOBBE, Directeur à la division câblerie des A.C.E.C., Charleroi

M. OSTY, Directeur technique à la société industrielle de liaisons électriques, 64bis, rue de Monceau, Paris 8e

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ANNEX IV

SEVENTH REPORT

CONCERNING THE ORGANISATION OF RESCUE ARRANGEMENTS FOR 1967 AND 1968

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INTRODUCTION

I. This report is concerned with progress in the organisation of rescue arrangements in the Member Countries and in the United Kingdom for 1967 and 1968. As in previous years, developments in this field have been closely linked with the general situation in the coal mining industry. This is however not so clearly reflected in the overall numbers of rescue stations in existence and of rescue personnel employed.

At 31.12.68, the number of rescue stations had dropped from 204 in 1966 to 203 and the number of rescue workers employed had fallen from 11,580 in 1966 to 11,198. The fact must however be borne in mind that, for France, the report includes for the first time 22 rescue stations and 774 rescue workers in the Centre-Midi coal-field, whilst up to and including the Sixth Report only the two main coal-fields, Nord/Pas-de-Calais and Lorraine, had been reflected in the figures.

Taking these changes in the data into account, the number of rescue workers per thousand underground workers in the Community and in the United Kingdom rose from 16.6 in 1966 to 20.5 in 1968, which represents an appreciable increase of 23 %.

II.1. In the course of their periodic exchanges of visits, rescue station supervisors have, during the period under review, visited the rescue stations at Lens (Nord/Pas-de-Calais), Friedrichsthal (Saar) and Merlebach (Lorraine).

They have thus been able to gain information at first hand on current progress in the organisation of rescue arrangements in these areas and to extend their knowledge on special procedures employed to prevent and fight fires.

The following practical problems, among others, were studied:

- Procedures for reaching trapped men
- Rapid means of checking on the danger of explosion in gas mixtures by means of a new type of explosimeter
- Telemetering of hot spots in galleries in which there is a danger of fire
- Reopening a section, examined with reference to a practical instance
- Employment of the hydromechanical process devised for the erection of plaster stoppings and the advantages of this process.

2. The terms of reference of the experts on rescue matters mentioned in the Introduction to the Fifth Report on the organisation of rescue arrangements have since been extended as follows:

- Comparative survey of regulations and directives concerning rescue arrangements and medical drawn up by the mining authorities in the Member Countries and the United Kingdom and analysis of experience gathered in these fields

- Study of the standards to which fireproof clothing must conform in the various Member Countries and requirements of a general nature.

The annual reports of the Mines Safety and Health Commission give detailed information on the progress of this work (1).

(1) The latest (Sixth) Report was published in June 1969 and - like the Reports on the organisation of rescue arrangements - can be obtained free of charge from the Secretariat of the Mines Safety Commission, Commission of the European Communities, 29 rue Aldringer, Luxembourg.

A. 1) ORGANISATION OF MINE RESCUE SERVICES

Position as at: 31.12.1968

Rescue Stations and Rescue Workers

Country	German Federal Republic			France			Belgium				Italy	Netherlands	United Kingdom	Total
Coal-field	Ruhr	Aachen	Saar	Nord/Pas-de-Calais	Lorraine	Centre-Midi	Borinage	Charleroi Namur	Liège	Campine	Sulcis	Limburg		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
a) Central Rescue Station (responsibilities)	Essen-Kray 1,2,4,5,6	Höngen-Mariadorf 1,2,4	Friedrichsthal 1,2,3,4,6	Lens 1,2,4,6	Merlebach 1,2,3,4,6	(*)	Frâmeries 1,2,4,5,6	Marcinelle 1,2,3,4	Glain 1,2,3,4	Hasselt 1,2,4,6	Miniera Seruci 1,2,4	(**)	(***)	
b) Number of rescue stations	69	6	10	43	9	22	1	1	1	6	1	8	A = 13 B = 13	203
c) Number of rescue men	3 961	311	632	601	579	774	67	184	155	291	36	357	3 250	11 198
d) Total underground personnel employed	127 470	12 123	18 556	52 603	17 792	18 173	2 609	10 551	5 518	18 423	830	12 757	250 000	547 405
e) Rescue men per 1000 underground workers	31,0	25,7	34,1	11,4	32,5	42,6	25,7	17,4	28,1	15,7	43,4	28,0	13,0	20,5

(*) Centre-Midi : there is no central rescue station in the Centre-Midi.

(**) Netherlands : there is no central rescue station in the Limburg coal-fields.

(***) United Kingdom : Each rescue station usually serves mines within a 15-mile radius. They are subdivided into "Plan A" Stations and "Plan B" Stations.

Responsibilities

Reference number 1 = Organisation of rescue services
2 = Supervision of rescue men and rescue stations
3 = Permanent rescue brigade
4 = Training
5 = Co-ordination of safety equipment
6 = Research on rescue work

"Plan A" Stations : those having (in addition to a manager, an assistant manager and a team of instructors) their own permanent rescue brigade, whose members live on the station or nearby. They are assisted by a number of part-time rescue men in the mines served by the station.

"Plan B" Stations : those having a manager, an assistant manager and a team of instructors, but which do not have their own rescue brigade living on the station or nearby. These stations use part-time rescue personnel employed in the mines served by the station, who are organised in brigades.

A. 2) ORGANISATION OF MINE RESCUE SERVICES

Position as at: 31.12.1968

Catalogue of equipment including closed-circuit breathing apparatus operating for a period of at least two hours

Country	German Federal Republic			France			Belgium				Italy	Netherlands	United Kingdom	Total
Coal-field	Ruhr	Aachen	Saar	Nord/Pas-de-Calais	Lorraine	Centre-Midi	Borinage	Charleroi/Namur	Liège	Campine	Sulcis	Limburg		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Type of apparatus														
a) Dräger BG 160 A	625	70	183	-	108	-	24	14	24	84	34	55	-	1 221
b) Dräger BG 170/400	660	22	-	-	-	-	-	6	6	40	9	-	-	743
c) Dräger BG 172	754	19	29	-	37	-	20	30	20	14	-	48	-	971
d) Dräger 174	99	27	36	-	81	-	-	-	-	2	-	-	-	245
e) Dräger KG 210	-	-	-	-	-	-	-	-	-	-	13	-	-	13
f) AUER MR 11/32	-	2	-	-	-	-	-	-	-	-	-	10	-	12
g) AUER MR 54/400	36	1	-	-	-	-	-	-	-	-	-	68	-	105
h) AUER MR 56/400	56	1	-	-	-	-	-	-	-	-	-	-	-	57
i) FENZY 56	-	-	-	400	-	308	-	-	-	5	-	-	-	713
j) Pirelli 45	-	-	-	-	-	-	-	-	-	-	-	-	-	-
k) Pirelli 205	-	-	-	-	-	-	-	-	-	2	-	-	-	2
l) BBM Aerecheon	-	-	-	-	-	-	2	-	-	2	-	-	-	4
m) BBM Aerophor	-	-	-	-	-	-	-	-	-	-	-	-	200	200
n) Proto	-	-	-	-	-	-	-	-	-	2	-	-	800	802
o) Savox	-	-	-	-	-	-	-	-	-	-	-	-	150	150
p) Normalair	-	-	-	-	-	-	-	-	-	2	-	-	-	2
q) Aerorlox	-	-	-	-	-	-	-	-	-	2	-	-	-	2
r)														
Total	2 230	142	248	400	226	308	46	50	50	155	56	181	1 150	5 242
Per group of 100 rescue men	56,1	45,7	39,2	66,5	39,0	39,8	68,6	27,2	32,2	53,1	155,0	51,0	35,4	46,8

Years: 1967 und 1968

B. NUMBER OF RESCUE OPERATIONS PERFORMED BY MEN WEARING CLOSED-CIRCUIT BREATHING APPARATUS

Cause	Firedamp or dust			Outburst of natural gas			Pit fires			Underground combustion			Opening-up of stoppings			Miscellaneous causes			Total		
Coal-field	a)+	b)++	c)+++	a)+	b)++	c)+++	a)+	b)++	c)+++	a)+	b)++	c)+++	a)+	b)++	c)+++	a)+	b)++	c)+++	a)+	b)++	c)+++
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
1. Ruhr	1	-	13	-	3	224	-	4	432	-	17	4 201	-	14	2 919	-	28	545	1	66	8 334
2. Aachen	-	-	-	-	-	-	-	1	31	-	-	-	-	-	-	-	3	19	-	4	50
3. Saar	-	-	-	-	8	57	-	2	10	-	3	26	-	3	212	-	-	-	-	16	305
4. GERMANY	1	-	13	-	11	281	-	7	473	-	20	4 227	-	17	3 131	-	31	564	1	86	8 689
5. Nord/Pas-de-Calais	-	-	-	-	-	-	1	1	20	-	1	10	-	-	-	-	-	-	1	2	30
6. Lorraine	-	-	-	-	1	6	-	2	332	-	-	-	-	-	-	1	1	10	1	4	348
7. Centre-Midi	1	-	39	1	1	36	-	-	-	-	10	894	-	-	-	-	1	5	2	12	974
8. FRANCE	1	-	39	1	2	42	1	3	352	-	11	904	-	-	-	1	2	15	4	18	1 352
9. Borinage	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10. Charleroi-Namur	-	-	-	1	-	4	-	-	-	-	-	-	-	-	-	-	1	3	1	1	7
11. Liège	-	-	-	-	-	-	-	-	-	-	3	297	-	-	-	-	7	16	-	10	313
12. Campine	-	-	-	-	-	-	-	1	4	-	-	-	-	-	-	-	-	-	-	1	4
13. BELGIUM	-	-	-	1	-	4	-	1	4	-	3	297	-	-	-	-	8	19	1	12	324
14. ITALY (Sulcis)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15. NETHERLANDS (Limburg)	-	-	-	-	-	-	-	3	21	-	-	-	-	-	-	-	-	-	-	3	21
16. UNITED KINGDOM	-	1	100	-	-	-	-	3	1 220	-	12	700	-	2	150	3	5	94	3	23	2 264
17. COMMUNITY + UNITED KINGDOM	2	1	152	2	13	327	1	17	2 070	-	46	6 128	-	19	3 281	4	46	692	9	142	12 650

a)+ = Rescue of personnel.
b)++ = Rescue of materials.
c)+++ = Number of air-purifying cartridges used in these operations.

C. ACCIDENTS TO RESCUE MEN DUE TO THE WEARING OF GAS-MASKS

1967 and 1968

COAL-FIELD	Serious accidents		During practice	
	not fatal	fatal	not fatal	fatal
(1)	(2)	(3)	(4)	(5)
1. Ruhr	-	-	-	-
2. Aachen	-	-	-	-
3. Saar	-	-	-	-
4. GERMANY	-	-	-	-
5. Nord/Pas-de-Calais	-	-	-	-
6. Lorraine	-	-	-	-
7. Centre-Midi	-	-	-	-
8. FRANCE	-	-	-	-
9. Borinage	-	-	-	-
10. Charleroi-Namur	-	-	-	-
11. Liège	-	-	-	-
12. Campine	-	-	1	-
13. BELGIUM	-	-	1	-
14. ITALY (Sulcis)	-	-	-	-
15. NETHERLANDS (Limburg)	-	-	1	-
16. UNITED KINGDOM	-	-	-	-
17. COMMUNITY + UNITED KINGDOM	-	-	2	-

D. COMMENTS, ADDITIONAL INFORMATION AND IMPORTANT CHANGES IN RELATION TO 1965/66

I. FEDERAL REPUBLIC OF GERMANY

1. Essen-Kray Main Rescue Station

a) Re A.1) Rescue stations and rescue workers

The number of rescue stations associated with the Essen Main Station reduced to 69 as the result of new rationalisation measures applied in the Ruhr collieries. The number of rescue workers has for the first time fallen below 4,000, i.e. 3,981 representing 3.1 % of underground personnel.

b) Re A.2) Closed-circuit breathing apparatus

The number of closed-circuit devices was reduced to 2,230. Most of these are now of the type with a reserve oxygen capacity of 400 litres. The percentage of the total now accounted for by closed-circuit breathing apparatus is 72 %.

c) Re B) Number of operations

During the period under review, there was a drop in the number of operations involving rescue teams.

In 1968 there was a serious firedamp explosion which cost the lives of 17 miners. Among them were 4 members of rescue teams, who, however, were not present as rescue workers.

The percentage of operations concerning mine fires and explosions is in sharp decline. More than 60 % of operations concerned the inspection and reopening of fire areas and operations in foul air.

Operations to reopen fire areas sometimes required extensive preparatory measures and, in many cases, extended over a fairly long period. All these operations have been commented on at length in the annual reports of the Main Station at Essen, which have been sent to the members of the working party for their information.

d) Results of research and development work

Breathing apparatus

During the period under review, tests have been carried out on accessories for breathing apparatus. It is worthwhile mentioning in particular the tests carried out on an air coolant for closed-circuit oxygen apparatus and on a new alkali coolant, Dräger 9 x 18 -28, from which improved yield is obtainable thanks to the use of a larger number of filters.

The research programme undertaken by the Commission of the European Communities to improve breathing apparatus is practically complete. The results are being analysed in conjunction with the Main Station at Hasselt (Belgium) and the University of Liège.

CO-filter self-rescuers

The Essen Main Station has completed the approval tests on the Dräger filter self-rescuer, model 810. The apparatus has already received official approval for use in German mines by the German Mine Rescue Commission, and its application has been authorised by all the Oberbergämter.

In 1967 and 1968, the filter self-rescuers were used as escape devices in 11 instances (mine fires and explosions) by a total of 210 miners.

Firefighting and fire prevention

The section of the Essen Main Station concerned with prevention of fire has assisted in the drafting of "Directives for the closure of mine workings and closure by damming of abandoned workings".

For the first time powder extinguishers have been constructed underground to protect against fire hydraulic installations which still operate with mineral oil. The design of these devices has been approved by the Main Centre.

Attempts have been made in conjunction with a number of mining companies to utilise the ash from electrostatic dust separators as a compression material for the dams. This material proved, on the whole, to be suitable for this purpose.

Moreover, during the last quarter of 1968, the first tests on the "Blitzdämmer" packing material were carried out. It will not be possible to say whether this material is suitable for the purpose until the tests have been concluded.

Moreover, in neighbouring workings, the material "Anhydrit" has been used in dams to seal off mine workings and for dams in roadhead areas.

2. Friedrichsthal Main Rescue Station (Saar)

a) Wider responsibility

At the end of 1967, the area of responsibility of the Main Station was extended to protection against explosions and to underground dust control.

b) Regulations, plans and instructions

During the period under review, the following regulations, plans and instructions concerning rescue and protection against fire and explosion were modified or redrafted.

- Principles for the organisation of rescue services in coal-mines of 9.5.67
- Measures to prevent the spread of coal dust explosions in underground coal-mines of 8.12.67
- Measures to prevent flooding or escapes of poisonous gas of 12.12.67
- General rescue plan, position at 15.7.67
- Directives of the Oberbergamt of the Saar and Rhineland-Palatinate concerning the use of flame cutting torches; welding equipment, welding torches and corrective devices in coal-mines, of 20.7.68
- Directives of the Oberbergamt of the Saar and Rhineland-Palatinate for the use of devices for the measurement and detection of CO in coal-mines, of 20.7.68
- Plan for the training of specialised overmen in protection against explosion
- General plan, position at 1.9.68
- Instructions for overmen specialising in protection against explosions, of 30.5.68

- Instructions for personnel in charge of stone-dusting, application of anti-dust products and construction and maintenance of dams against explosions, of 16.7.68

c) Improvement of alarm systems

During the period under review, all rescue and gas control teams of Saarbergwerke AG were equipped with a UHF radio alarm system. The rescue teams are grouped into 15 alarm sectors. A total of 560 UHF alarm receivers without intercom and 40 with intercom were installed in the homes of members of rescue teams. The alarm is broadcast from a central UHF transmitter located in a high position at the Main Rescue Station.

d) Results of research and development work

CO measurement and detection devices

The large-scale test on underground CO measurement and detection devices was successful.

Hydro-mechanical process for the erection of plaster dams

The hydro-mechanical process for the erection of plaster dams was developed for possible industrial use. At the end of 1967 and at the beginning of 1968, tests were effected in conjunction with the Versuchsgrubengesellschaft mbH, Dortmund; two plaster dams 1.50 m in thickness withstood several violent explosions. As a result, the Oberbergamt of the Saar and Rhineland-Palatinate approved for protection against explosions dams erected in Saaralit plaster having a minimum thickness of 1.50 m manufactured by the hydro-mechanical process for galleries up to 16 sq. m in section. Since then, the hydro-mechanical process has given very good results both for dams erected against fire and for dams used for the routine sealing off of mine workings (temporary dams).

II. BELGIUM

Coördinatiecentrum Reddingswezen, Hasselt

a) Re C) Accidents suffered by rescuers due to the wearing of gas protection apparatus

One rescue worker got into breathing difficulties during an exercise with a "Dräger BG 170/400" breathing device.

It emerged, during individual inspection before the exercise, that, when the rescue worker emptied the breathing bag each time he breathed in, the left-hand wall of the bag, instead of aligning itself normally, was drawn in beneath the plate on which the control lever for extra air on demand was located.

The fold created produced an additional thickness which prevented the demand control lever from being depressed sufficiently. The automatic feed mechanism did not function at all or at least only when very powerful suction was set up in the breathing bag.

As a result of this incident, various measures were taken:

1. During the individual inspection before the exercise, both the apparatus and the wearer's lungs must be rinsed with oxygen. For this, when the oxygen cylinder is open, the wearer will breathe in from the apparatus and breathe out to the atmosphere through the nose. At this point the operation of the automatic admission should be clearly heard. After that the breathing bag is filled by pressing the additional feed button so that the bladder is fully distended.

2. The personnel responsible for the maintenance of the apparatus must ensure that the breathing bags placed in the devices and those kept in reserve are properly distended, so that no creases are formed in them.

b) Results of research and development work

Breathing apparatus

The joint work on improving the physiological conditions for the wearing of breathing apparatus has been concluded.

Underground use of polyurethane foam

The programme of tests on flame spread over the surface of a pulverised urethane coating on the walls of a gallery with a view to the use of this material underground use has also been brought to a conclusion. The Coördinatiecentrum Reddingswezen has drawn up a detailed report which it has supplemented by incorporating in it the results of tests carried out by other bodies.

III. FRANCE

a) General

During the period under review the seven Centre-Midi collieries (1) were concentrated into a single complex, and the present report contains for the first time information concerning rescue work in the Centre-Midi mines.

b) Re B) Number of operations

With regard to the Lorraine coal-field, operations for the salvage of material during fire outbreaks included that at the Folschwiller colliery from 2nd to 10th April 1967, which involved the erection of three plaster dams and required 327 air purifying cartridges.

The two operations arising from "other causes" both took place above ground, one at St. Charles on 9.9.68, for a case of poisoning in a quarry gallery, the other on 15.3.68, for an electrical fire outbreak.

With regard to the Centre-Midi coal-field, the operations to be noted are the one following the accident at the Charles pit on 3rd May 1968, for which a special report has been submitted to the Mines Safety and Health Commission, and one in the Dauphiné to rescue the victim of a sudden outburst of firedamp.

Finally, nine of the ten operations for mine fires took place at the Houillères d'Aquitaine and required the use of 882 air purifying cartridges.

VI. UNITED KINGDOM

a) General

Since 1st April 1967, the National Coal Board has organised rescue services on a national basis. The 26 rescue stations and their staff are under the control and direction of the National Rescue Service, responsibility for which has been entrusted to the Assistant General Manager for Production (special functions).

The country is subdivided into 7 areas, each one under the control of an Area Manager for Rescue Stations. Those in charge of the stations in each area report to the Area Manager.

(1) Loire, Cévennes, Blanzy, Aquitaine, Provence, Auvergne and Dauphiné.

In order to provide close links between the National Rescue Service and the collieries, 7 Area Rescue Committees have been set up. They include the Assistant Area Manager, the Production Managers and the Colliery Managers, under the chairmanship of the Assistant General Manager for Production.

b) Results of research and development work

Heat exchanger self-rescuers

In 1968, the National Coal Board decided to place an order for a suitable number of self-rescuers (with heat exchanger) so that every man working underground would have his own self-rescuer. It is expected that every miner will be so equipped by March 1970. When a colliery is equipped with self-rescuers, it is forbidden for anyone to go underground without his apparatus.

"Aerolox Liquid Oxygen" apparatus

Towards the end of 1968, the "Aerolox Liquid Oxygen" device passed the official approval tests of the Ministry of Power. The National Coal Board ordered 550 devices and these will be delivered during the second half of 1969 and beginning of 1970.

Use of polyurethane foam underground

In 1968, the National Coal Board prohibited the use of polyurethane foam underground and instituted stringent control over the coating materials used underground.

ANNEX V

REPORT ON THE CHARACTERISTICS AND ELECTRICAL PROTECTION OF CABLES SUPPLYING MOBILE MACHINES (COAL-CUTTERS, LOADING MACHINES ETC.) USED UNDERGROUND IN COAL-MINES IN THE VARIOUS COMMUNITY COUNTRIES

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1. Explanation of the terms of reference

The Mines Safety Commission approved on the 8th April 1960 and on the 27th/28th April 1964 the two Recommendations set out below :

a) "Protection of underground electrical networks against the risk of electrocution" (1);

b) "Protection of underground electrical networks against fire and firedamp-explosion risks" (2).

In order to arrive at a more precise formulation of certain conclusions from these two Recommendations the Safety Commission empowered the Working Party on "Electrification" to investigate the practical measures adopted to ensure safety of the systems and to prevent accidents by electrocution, fire risk or firedamp-explosion risk (see Third Report of the Mines Safety Commission, page 38, point 2).

In the framework of this investigation the first task imposed upon the Working Group was defined as follows: "To determine the present state in the various Community countries of the existing devices for ensuring the safety of underground networks carrying low- or medium-tension current (up to 1 100 V) and of the cables supplying mobile machines, taking into account the characteristics of such cables" (Mines Safety Commission in its session of 24th April 1967).

The Working Party herewith presents a report covering that part of the task which appears to involve the greatest risk to safety, namely the supply cables to machines which are moved - in the face or during roadway drivage - while still being supplied with current and which have for the most part a high current carrying capacity. The protective measures to be taken are seen to be particularly important because of the hazards that can arise.

2. Characteristics and electrical protection of cables supplying mobile machines (coal-cutters, loading machines etc.) used underground in coal-mines in the various Community countries.

Initially the Working Party drafted a classification of the movable machines used in coal-mines (portable, mobile, machines which can be advanced or flitted, and semi-stationary machines, see Annex I).

The present report refers to the machines entered in this classification as mobile (machine group II), which the Working Party considered of priority importance in their work.

On the basis of the information tabled by the different delegations the various documents annexed and discussed here were prepared. In doing this, the attempt was made to give precise definitions of certain concepts which differ from one country to another. These documents are :

a) a classification of the cables supplying mobile machines, and including a detailed description of these cables (see Annex II).

This classification also includes the cables which are to be introduced into service in the near future, Certain older types of cable, which are still used while stocks last, were not included.

This classification is not intended to affect the normal use of the cables, nor the regulations in force in the individual countries.

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(1) See Second Report of the Mines Safety Commission, p. 11.

(2) See Third Report of the Mines Safety Commission, p. 379.

b) an explanation of the concept "screening of electrical cables", which lists the various types of screen and defines their functions (see Annex III).

c) a description of the main electrical devices used to protect cables supplying mobile machines (see Annex IV). In this description the devices are classified on the basis of the principle on which they operate, which is illustrated by circuit diagrams.

d) a table of the most important electrical protective devices for cables supplying mobile machines (see Annex V).

This table indicates the protective devices used in the individual countries for the various types of cable. It also shows how protection against the different types of fault which have been recorded is provided. The component or components of the protective device appropriate to each type of fault is indicated. The table also shows to what extent the protection which can be given depends on the type of cable in use. It can be seen that, in certain cases, several protective components can come into action for the same type of fault.

The investigation shows the present state of the most important protective devices used in the Community countries. These protective devices make it possible to ensure electrical protection of the supply networks feeding mobile machines according to the types of cable in use.

This study makes it possible to conclude that appropriate choice of the type of cable and of the associated protective equipment makes it possible to provide protection against the majority of types of fault which can occur with these cables.

Annex I

Classification of Movable Machines

A. Machine group	B. Category	C. Definition	D. Examples	E. Essential features demanded of supply cables
I	portable	held or guided by hand during operation	hand drills	flexibility and light weight
II	mobile	moved during operation (while cables are live)	coal-cutters (with integral winch / with separate winch) continuous miners shuttle cars loading machines drilling jumbos heading machines	flexibility and robustness
III	machines which can be advanced or flitted	advanced at irregular intervals during operation (while cables are still live)	afc driveheads monorail-suspended transformers and gate-end boxes (relays etc.)	mechanical strength is of the first importance
IV	semi-stationary	advanced with current switched off, but cable connected	roadway transformers, gate-end boxes (relays etc.)	mechanical strength is of the first importance

Annex II

Classification of the Cables for Mobile Machines

Explanation of the symbols used (1)

Capital letters :

A : cables with a single collective screen (A.2 and A.3) or a mass conductor which serves at the same time as a single collective screen (A.1).

B : cables with individual metallic screens for each core (B.2 and B.3) or a divided mass conductor serving at the same time as individual screens (B.1).

C : cables with the combined characteristics of groups A and B.

D : cables with individual semi-conducting screens in which good longitudinal conductivity is guaranteed (D.1, D.2 and D.3).

Indices :

1 : cables with a mass conductor serving at the same time as a collective screen or as individual core screens (A.1, B.1, C.1 and D.1).

2 : cables with a single mass conductor set asymmetrically with respect to the phase cores (A.2, B.2 and D.2).

3 : cables with a mass conductor divided into three cores set symmetrically with respect to the phase cores (A.3, B.3 and D.3).

Description of the cables :

A.1 : cable with 3 phase cores and 1 concentric mass conductor which serves at the same time as collective screen.

A.2 : cable with 4 cores, one serving as a mass conductor, with a collective screen.

A.3 : cable with 3 phase cores, a mass conductor divided into 3 cores set symmetrically, and a collective screen.

B.1 : cable with 3 phase cores, with a mass conductor divided into 3 parts serving at the same time as individual core screens.

B.2 : cable with 4 cores, one serving as mass conductor, and with individual core screens.

B.3 : cable with 3 phase cores, a mass conductor divided into 3 cores set symmetrically, individual core screens.

C.1a : cable with 3 phase cores, a concentric mass conductor serving at the same time as a collective screen and individual screens.

C.1b : cable with 3 phase cores, a mass conductor divided into 3 parts serving at the same time as individual core screens, and a collective screen (2).

D.1 : cable with 3 phase cores, a concentric mass conductor serving at the same time as a collective screen, and individual core screens of semi-conducting material.

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(1) See note at the end of page V, 12 and the illustrations of cable types on page V, 13.

(2) In the Netherlands, to ensure better continuity of the masses, use is made of the 4th core which is electrically connected over its whole length with the 3 individual mass screens. In cable C.1b, it is central.

D.2 : cable with 4 cores one of which serves as a mass conductor, with individual screens of semi-conducting material.

D.3 : cable with 3 cores, a mass conductor divided into 3 parts set symmetrically, with individual core screens of semi-conducting material.

N O T E :

All the cables may have a certain number of cores or pairs of auxiliary cores which are insulated and can be used as pilot cores or monitoring cores.

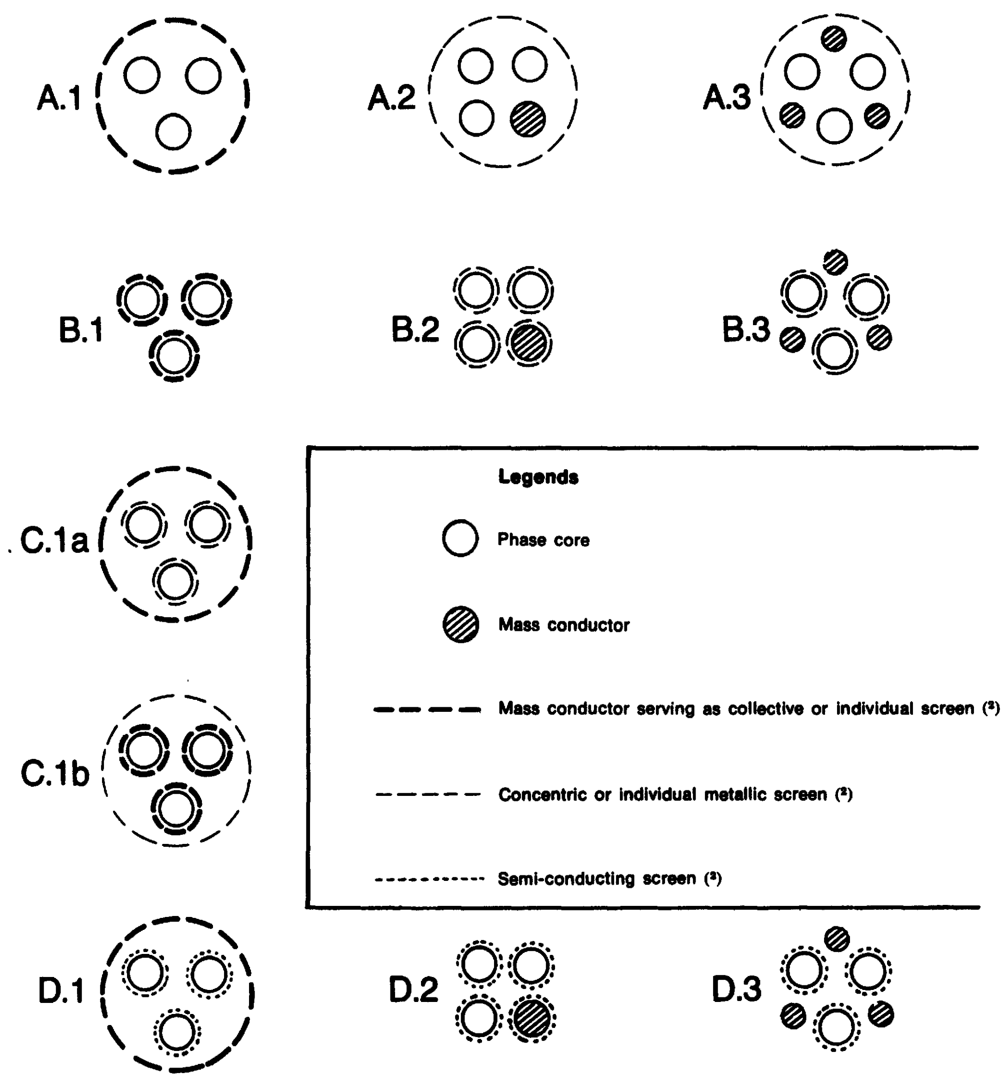
The collective screen or the mass conductor which also serves as a collective screen may in some cases also act as armouring.

The various possible ways of using these screens are set out clearly in Annex III.

In Great Britain the mass conductor is usually referred to as the carthing conductor.

Annex II

Cables for mobile machines
Types in service or to be introduces (1)



(1) This diagram does not take into account the possible use of auxiliary conductors (polarised conductors and pilote conductors)

(2) See Annex III

Annex III

Explanatory notes on the concept of "screening of electrical cables"

The "screen" on a cable is understood to mean a conducting envelope surrounding one or several insulated main conductors.

The screens are made either of metal or of semi-conducting elastomer or plastomer material, in which one or several copper conductors are embedded to ensure good longitudinal conductivity.

The screen is collective when it is set concentrically around all the conducting cores.

The screen is individual when it is set separately round an individual conducting core.

The main function of a screen is to allow for the detection of an insulation fault on main conductors, this detection being based on the production on the screen of a fault current to earth. For this reason the screen is generally electrically connected to the mass, which is in turn earthed.

In certain cases, the screen is not directly connected to the mass but is polarised. In this instance, it still serves the same main purpose but also makes it possible to have constant electrical monitoring of the cable in respect of damage caused by the penetration of any conducting object which may be connected to the mass or to earth.

When a collective screen has a sufficient degree of conductivity, it can also serve as a mass conductor. The same is true of the individual screens, when the totality of these screens has sufficient conductivity. In Germany the terms screen ("Schirm") is then replaced by two different terms, respectively "concentric protective lead" ("konzentrischer Schutzleiter") or "protective lead in the form of an individual core sheath" ("Schutzleiter als Einzeladerhülle").

When a collective screen has a high degree of mechanical strength, it can also serve as an armouring which protects the cable against mechanical damage.

In the Netherlands, use is made of cables fitted with individual screens of high conductivity which also play a part in the structure, serving as "safety armouring" ("veiligheidsscherm").

Annex IV

Description of the main electrical protection equipment for cables supplying mobile machines

ELECTRICAL PROTECTION OF FLEXIBLE CABLES SUPPLYING MOBILE MACHINES

The protection devices concerned ensure that the electrical network is automatically isolated from its supply source in the event of a fault which constitutes a risk for the workers or for the mine itself.

The main devices involved can be classified as follows, according to the principle on which they operate, each group being designated by a symbol.

1) CB ..... Devices based on amperometric detection of the homopolar current.

By means of a magnetic torus (called in England "core-balance", hence the symbol CB), these devices detect the vectorial resultant of the three currents flowing in the three phase cores, this resultant being known as the "homopolar current".

The fault current between the phase and the mass is restricted to a certain maximum value by an impedance between the neutral point and the mass (diagram I indicates the principle of this system).

Since it is possible to put in a core balance on each line in the network, only the line where the fault occurs will actuate the device, selectivity being assured as long as the impedance between the neutral point on earth is not too high.

An application in a network with a weakly-insulated neutral point utilised in the Netherlands is shown in diagram II.

In this system, all the live elements are set inside a "safety armouring" (known as "veiligheidsscherm" in the Netherlands), which is earthed, the intention being to ensure integral protection of the elements contained therein. This armouring consists essentially of the armoured protection and screens of the electric cables as well as the metal sheathing of all the equipment in the installation. The entire system has a very low electrical resistance.

This safety armouring is connected to the neutral point of the supply transformer by a reactance winding, the impedance of which is determined by the maximum fault-current intensity which occurs in the event of an insulation fault between the phase and the mass (earth).

In underground workings where the methane content generally does not exceed 1.5 %, this maximum permitted intensity is not more than 30 A (1). In underground workings covered by an exemption allowing a methane content up to 2 %, this maximum permitted value does not exceed 10 A.

From these values it is possible to calculate the minimum value for the impedance of the reactance winding for the various voltages.

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(1) In order to ensure protection against electrocution, making due allowance for the normal operating conditions of voltage, resistance and fault current, all of which are variable, in all cases

$I_f R_a$ is maintained $\leqslant$ 42 volts with

I_f maximum value of fault current which may not be cut off

R_a resistance of the entire system of safety armourings.

The following values are used :

	$CH_4 < 1,5$ %	$CH_4 < 2$ %
500 volts	9 or 29 ohms	29 ohms
865 volts	16 or 50 ohms	50 ohms

In the case of a short circuit between phase and mass, the current is cut off from the installation by the core-balance relay.

The response intensity, independent of the normal operating intensity, is 3 A. Cutting-off of the current is achieved in less than 300 ms. Where selective time-lag protection is provided, cutting-off of the current must be obtained within a period less than 1 second.

In order to ensure this cutting-off even where it may not have been achieved by means of the core-balance relay, a back-up relay (1) is added to the reactance winding, and this back-up relay cuts off the HT current in this event.

This core-balance system is supplemented by a control and monitoring system (diagram XI) based on a principle similar to that described under point 4 on page V, 21 (BS ..... safety block).

Each phase core of all the types of electric cables supplying mobile machines of all kinds is surrounded by an individual earthed screen, electrically connected to an additional mass conductor, the whole being surrounded by a collective polarised screen.

2) CBT ..... Devices based on amperometric and directional detection of the homopolar current (diagram III)

This system is capable of application in networks with strongly-insulated neutral points. In the event of a fault in such a network, the fault current is the sum of the capacitative currents of all the non-faulty phases.

A homopolar current thus arises in each line and the principle adopted for the networks with weakly-insulated neutral point can no longer be used.

But this fault current, which goes back to source via the faulty line, is more intense - in absolute terms - that the direct capacitative currents and is of opposite sign.

The vectoral sum of the voltage U_2 and the voltages U_1 and $-U_1$ thus allows of determining the direction of flow of the homopolar currents and - by means of a galvanometric relay and once the sensitivity threshold has been reached - of causing the actuation of the circuit-breaker on the faulty output or initiating the signal.

If the network is short, it is,however, necessary to provide a sensitising capacity between the neutral point and earth.

3) CI ..... Insulation-monitoring devices (diagram IV and V)

Using a continuous or rectified current, these devices continuously monitor the total resistance which exists between the entire network and the mass circuit, i.e. the insulation value of the network. Their operation is thus independent of the network capacities.

(1) The back-up relay is an amperometric relay with a time lag, which actuates the primary side of the supply transformer, when the core-balance relay on the secondary side does not trip. This device will be indicated by the symbol "BU".

The source of continuous rectified current is connected, first to one phase of the network or to the neutral of the network (diagram IV), or possibly to an artificial neutral (diagram V), and secondly, to the mass circuit.

A measuring device in series with the source indicates the insulation values. In addition, the voltage variation at the terminals of a resistance, proportional to the current variations, can after being amplified control a relay which actuates an acoustical optical signal, or both, once the warning threshold has been reached, as well as a second relay which provides protection by separation of the network from the source when the insulation drops below a second threshold, known as the tripping threshold (only one of these relays is shown in diagrams IV, V, VII, VIII and IX by the symbol R_1).

The disturbing effect of alternating currents and of transitory phenomena must be eliminated by means of a filter. This consists of a capacity which, in the event of the detection of a fault, produces a delay equal to the charging time of the capacity. This delay time varies as a function of the difference which exists at the moment of detection between the network insulation values before and after the occurrence of the fault. Allowance must generally be made for a delay of 100 ms, sometimes 200 ms, this being the delay required to allow the necessary time for measurement. Certain devices are, in addition, provided with an adjustable time-lag device, but it is desirable that these time delays should be kept to a minimum. Where used in combination with a CBT type device which operates rapidly, a certain time-lag in the insulation-monitoring device may be acceptable and even desirable.

These systems may be provided with a device which makes it possible to insert an artificial fault of a known value. If the network is isolated at the moment of measuring the artificial fault, all other conditions being maintained the same, particularly the feeding of the continuous voltage into the network, this makes it possible to check at will the accuracy of the indications given by the measuring device.

The measuring range of these devices is very wide, and adjustment of the warning and actuating thresholds is simple. The acoustic signal (1) must be capable of being switched off, but this is not true of the optical signal. The latter should go out only when the fault has been detected, in which case the acoustic signal should be restored automatically to its operating position.

An important feature of these devices is that they can monitor the network even when it is not live, so that there is no switching-on of faulty lines.

4) BS ..... Safety block (diagrams VI, VII, VIII, IX and XI)

The devices so designated are intended in particular to protect a flexible cable supplying the mobile machine, by cutting off the current in the following cases :

a) Contact between a polarised element of the flexible cable (screen, pilot core or monitoring core) with the mass.

b) Contact between a polarised element or the mass and a phase.

c) Breakage of the mass conductor.

d) Breakage of the monitoring conductor or of a pilot core intended to break before the phase cores when the cable is under physical stress.

e) Breaking of the interlocking circuit of the connectors.

f) Double fault between a phase and the mass conductor and between another phase and the polarised screen.

(1) The acoustic signal is no longer used in Germany.

The device illustrated in diagram VI comprises two relays : control relay R_2 and a fault relay R_3. When relay R_3 functions, relay R_2 is short-circuited and energises the bobbin of the contactor with which the block is associated, causing it to open. The block is connected to the monitoring conductor or to the screen, which is in turn connected at the cable end to the mass by means of a resistance and a diode. In diagram VI this system is called "block B". The device so constituted is actuated if cases a) to e) above occur. In the event of faults a) and b), switching-off in the block occurs in two stages : firstly R_3 is actuated, and then R_2 cuts out. However, for eventuality b), protection is achieved only if the capacity of the network is sufficiently high; however, this protection can always be ensured by the insulation-monitoring device which is normally employed in conjunction with this device.

Diagram VII shows an insulation-monitoring device with relay R_1 and a BS block with 2 relays : relay R_{2+3} for control and faults, and a double-fault relay R_4. This combined insulation- monitoring and safety-block device operates if any of the eventualities a) to f) occur, relay R_1 for fault b) and relay R_{2+3} for faults a) and c) to e).

If relay R_1 is provided with a time-lag, relay R_4 operates the switching-off if a fault of category f) occurs, i.e. if there is a double fault between phase and mass on the one hand, and phase and polarised screen on the other.

Diagram VIII (1), also shows an insulation-monitoring device CI with relay R_1 and block BS with two relays, one control/fault relay R_{2+3} and one double fault relay R_4. This combined insulation-monitoring and safety-block device is actuated for faults a) to f). The time-lag relay R_1 operates if there is a fault between phase and mass conductor or phase and polarised screen. Relay R_{2+3} operates without delay if there is a fault between phase and polarised screen and in the event of faults a) and c) to e) occurring.

The use of a time delay on relay R_1 with respect to relay R_{2+3} provides selective cutting-off of the flexible cable in the event of a fault between phase and polarised screen.

Relay R_4 causes cutting-off in the event of a fault between phase and polarised screen if the capacity of the networks is sufficiently high. In addition, it causes cutting-off in the event of occurrence of a double fault, between phase and mass on the one hand and between phase and polarised screen on the other.

Diagram IX corresponds to diagram VII but without relay R_4.

These systems are incorporated in the gate-end boxes and provide electrical protection of flexible cables for mobile machines, such as cutter-loaders, at the same time as providing remote control for these machines.

They require the use of a cable with at least 5 cores, including a collective screen or a set of individual screens or both.

If the cable is provided only with a single collective screen, this may be connected to the mass or may be polarised. If individual screens are provided, these are polarised if there is also a collective screen connected to mass. If there is no collective screen, the individual screens may be either polarised or connected to the mass. These screens are made of metal or of semi-conducting plastomers or elastomers; in the latter instance, copper cores must be used to ensure longitudinal conductivity.

The preceding remarks show that the various types of protection which can be given by a safety block vary with the type of cable used.

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(1) A more detailed explanation of this point is given in the annex to document N° 5693/2/67 under the title "Explanation of diagrams VIII of the combined insulation-monitoring and safety-block type".

A. With cables having a single-collective screen connected to the mass the following categories of protection can be achieved (1) :

1. Switching-off when the insulation between phase and mass or phase and screen drops below a certain preset value.

2. Switching-off when the insulation between polarised element and screen drops below a certain value.

3. Switching-off in the event of breakage of the monitoring conductor or the mass conductor or in the event of breakage of the screen if this serves as a mass conductor.

4. Safe disconnection of plug- and socket-connectors.

5. Prevention of unwanted starting-up of the machine by any fault in the cable.

B. If the single collective screen is polarised, the categories of protection listed under A are provided, with the addition of protection against penetration into the cable of any conducting object, as soon as this object touches the screen and provided that it is connected either to the masses or to earth. Protection is also provided in the event of breakage of the screen (2).

C. If the single polarised collective screen is replaced by individual polarised screens, then, in addition to the categories of protection listed under A and B protection is provided against impedance short-circuits between phases. Protection in the event of breakage of a phase will generally be assured since this fault rapidly brings about contact between phase and screen (3).

D. If the individual screens are connected to the mass, the categories of protection listed under A and C are provided, but not the category listed under B in connection with the penetration of a conducting object into the cable.

E. If the cable is provided with a collective screen connected to the mass and with individual polarised screens, all the categories of protection listed under A, B and C are ensured. In addition, there is also protection against penetration into the cable of any conducting object, even if this object is not connected to the masses or to earth, as soon as this object touches two screens (4).

5) DDI ..... Impedance-fault detectors (diagram X)

Originally intended to detect short circuits of limited amplitude (impedant faults), the impedance-fault detector compares the current intensities of the phases in a balanced three-phase network and causes the current to be cut off if a predetermined rate of unbalance occurs; it thus supplements the normal categories of protection which are not suitable for this purpose.

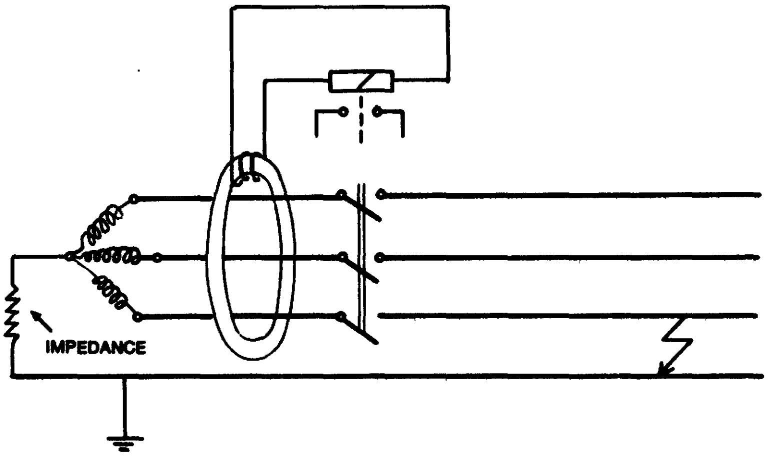
Diagram X shows an example of such a device : the three voltages flowing to the secondaries of three identical transformers connected to the network phases are rectified at certain point and compared in a relay-balance circuit which is tripped if the difference between the voltages reaches a predetermined, adjustable threshold value.

The relays of the balance system monitor a switching-off circuit which is so arranged that the asymmetrical features of the transitory conditions (switching-on under load, starting-up of motors) have no effect.

(1) See annex II, cable types A.1, A.2 and A.3.
(2) See annex II, cable types A.2 and A.3.
(3) See annex II, cable types B.2, B.3, D.2 and D.3.
(4) See annex II, cable types C.1a and D.1.

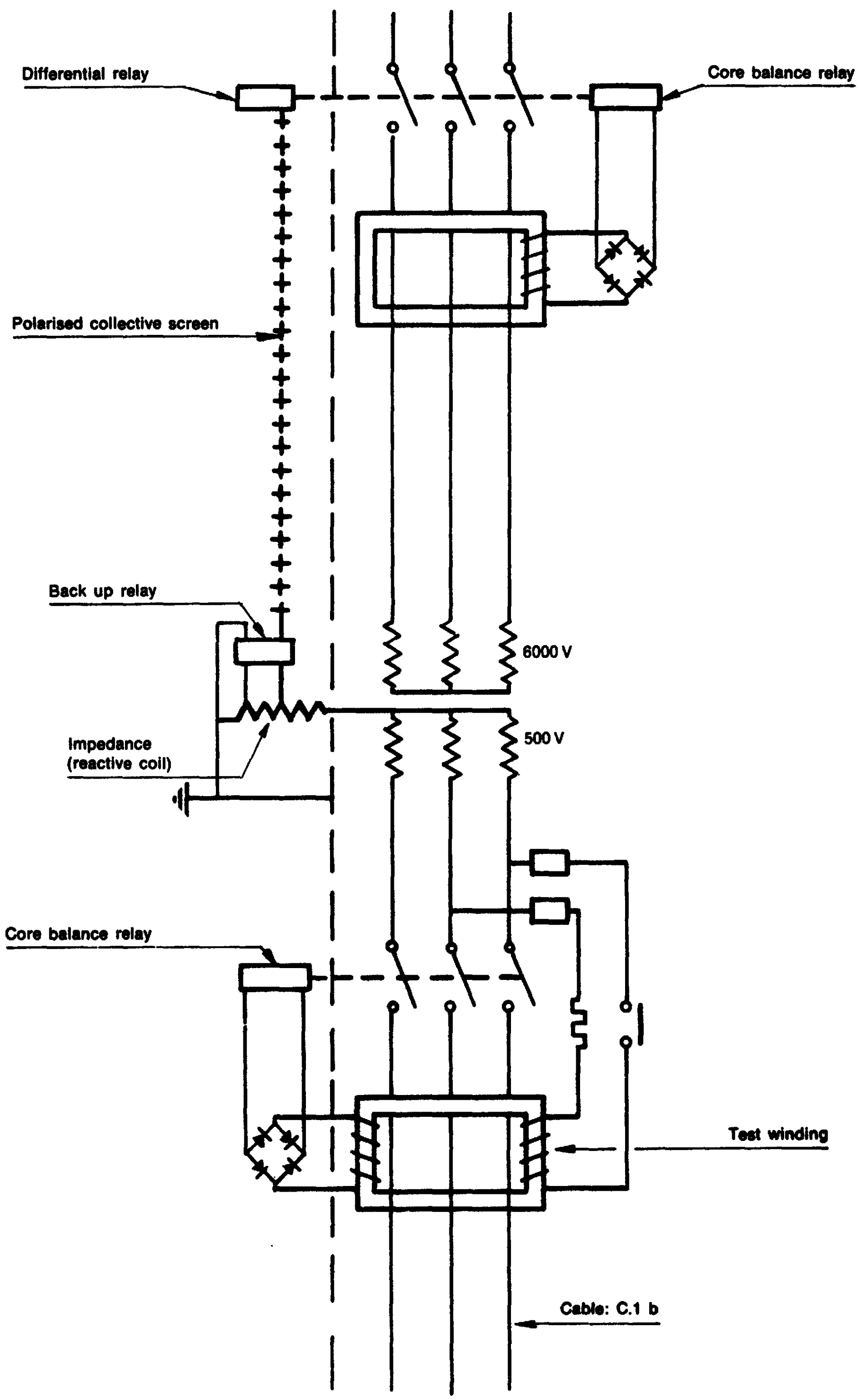
Annex IV

DIAGRAM I – TYPE CB



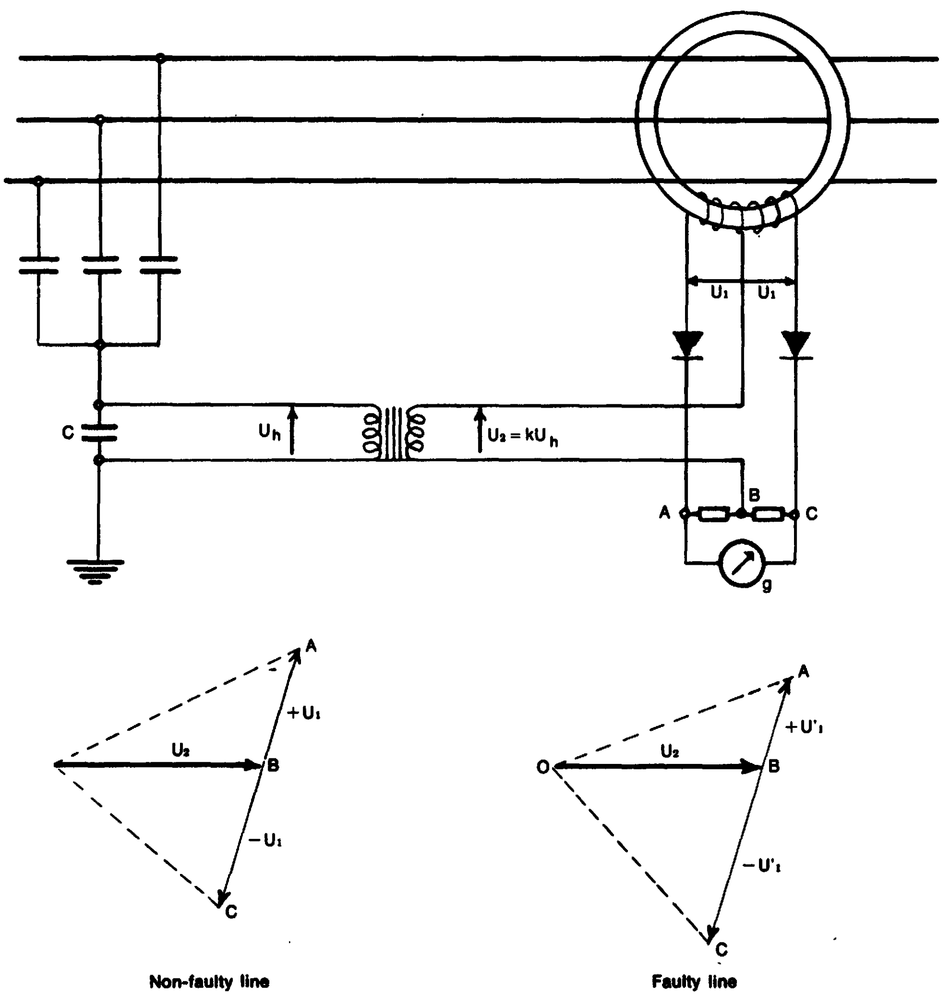
Annex IV

DIAGRAM II – TYPE CB



Annex IV

DIAGRAM III – TYPE CBT



Annex IV

DIAGRAM IV – TYPE CI

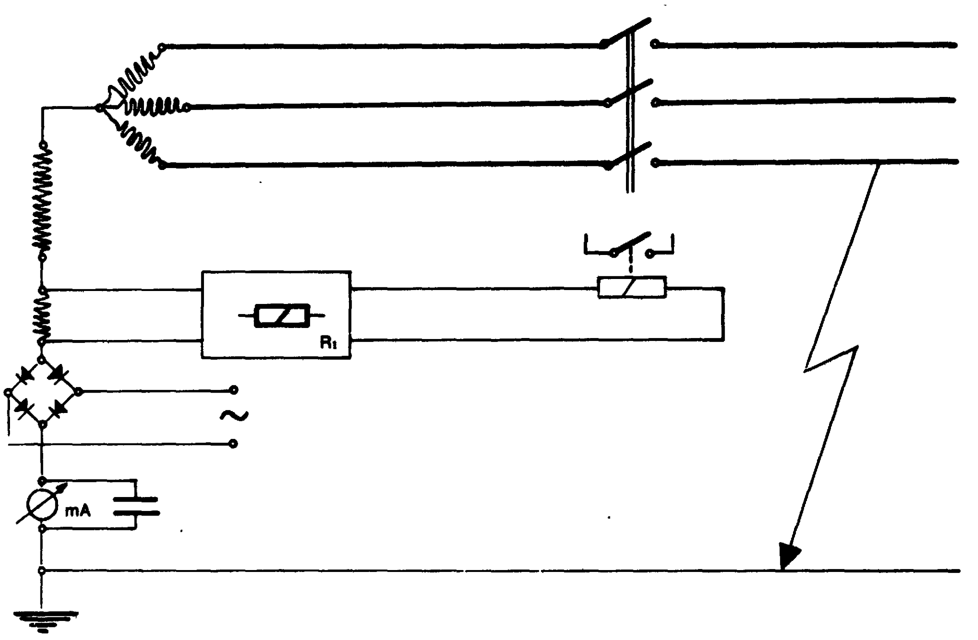
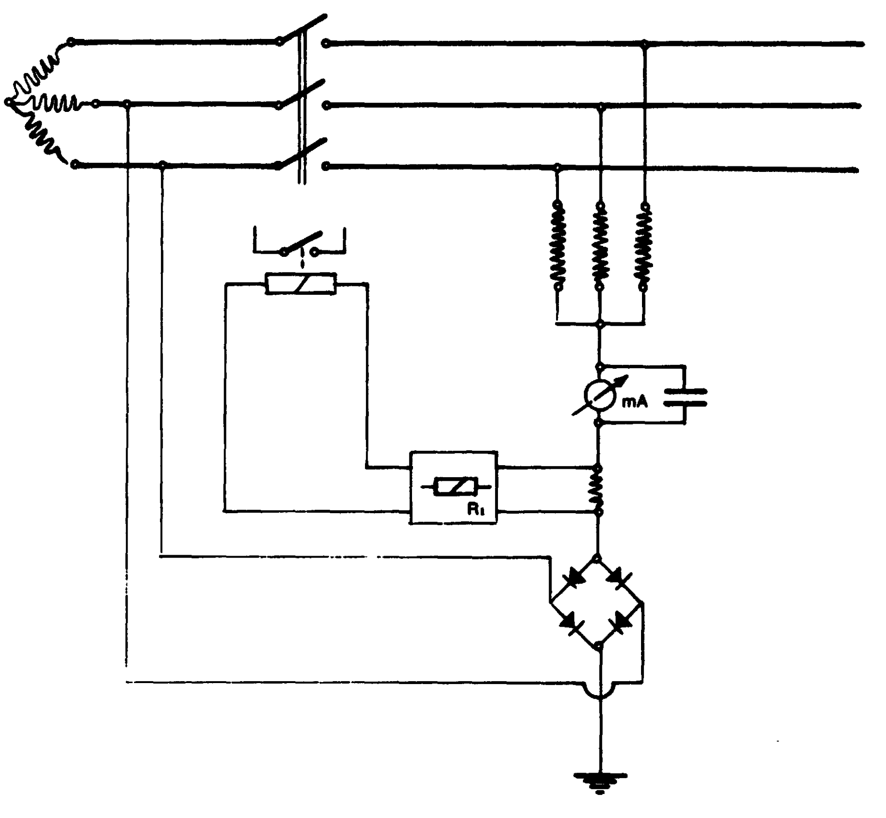


DIAGRAM V – TYPE CI



Annex IV

DIAGRAM VI – TYPE BS

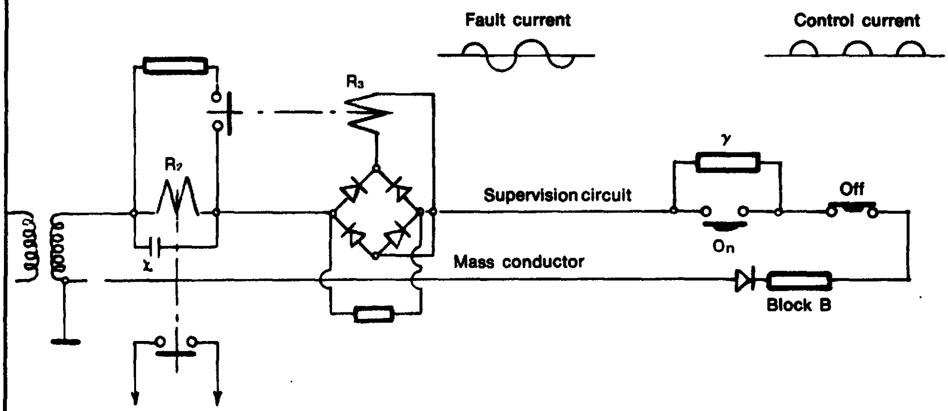
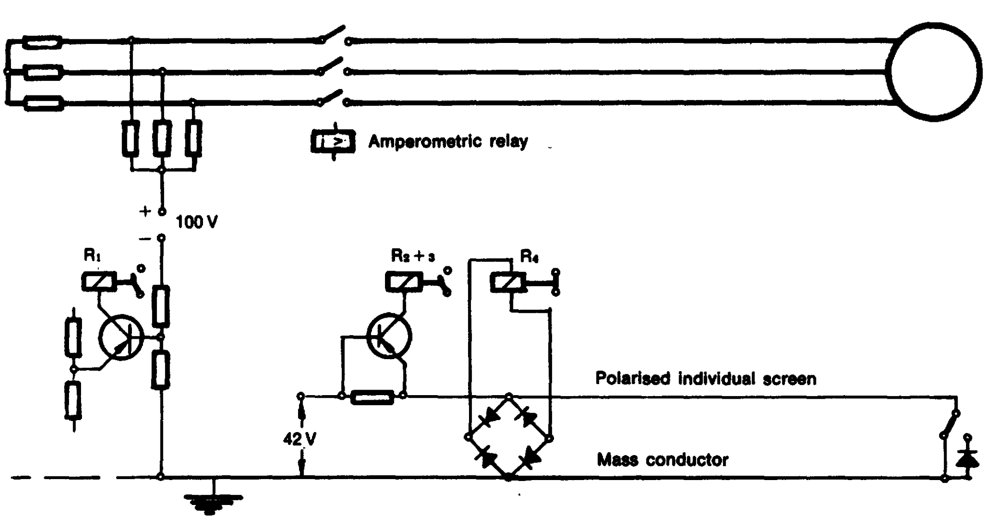
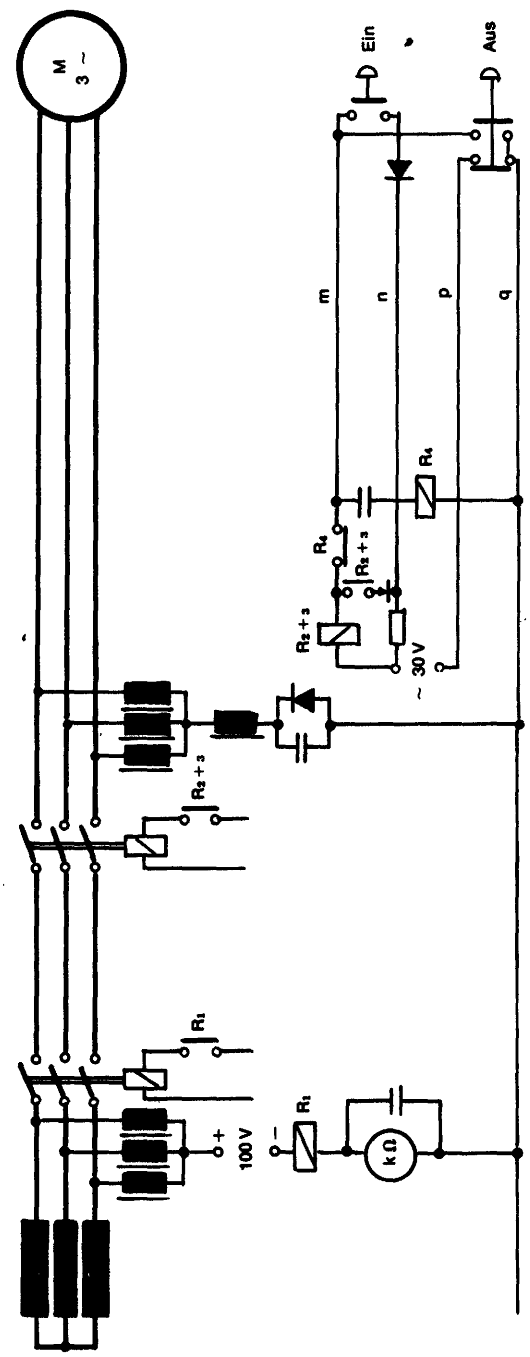


DIAGRAM VII – TYPE CI + BS



Annex IV

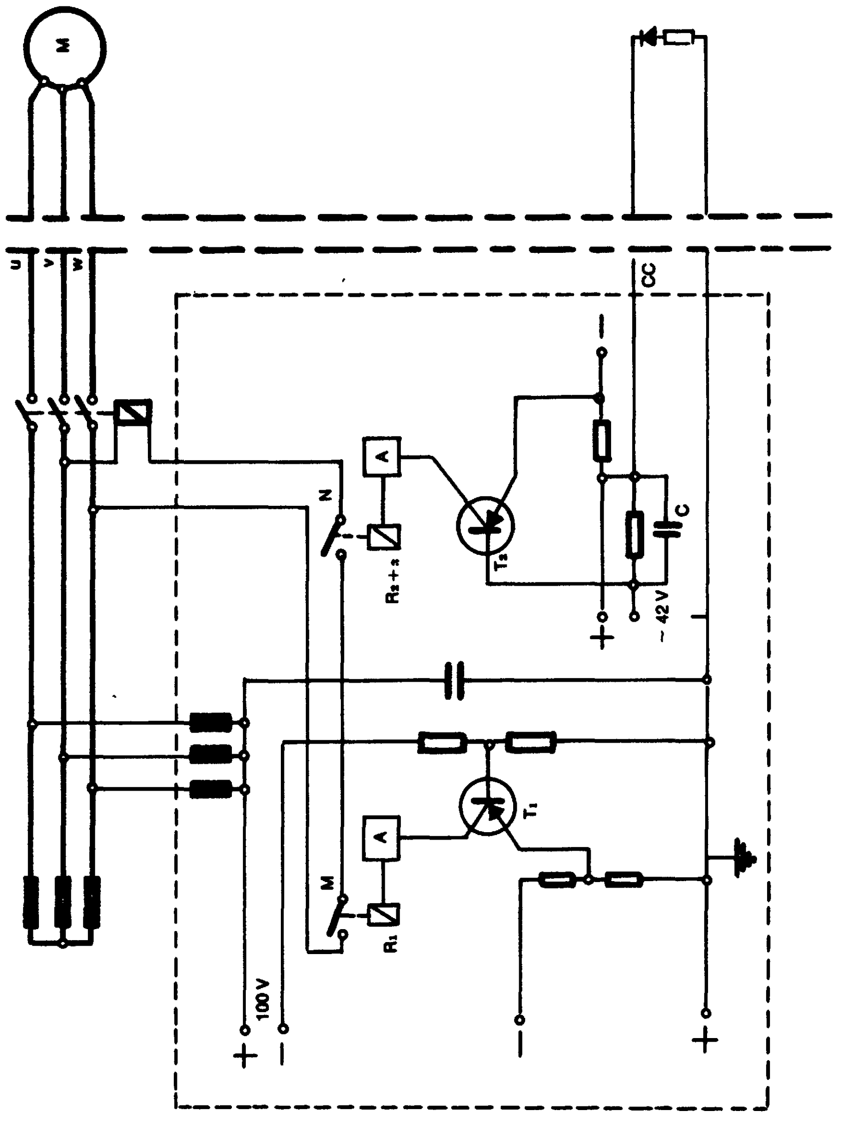
DIAGRAM VIII – TYPE CI + BS



m : Individual polarised screen
n : Polarised conductor
p : Pilote conductor
q : Mass conductor

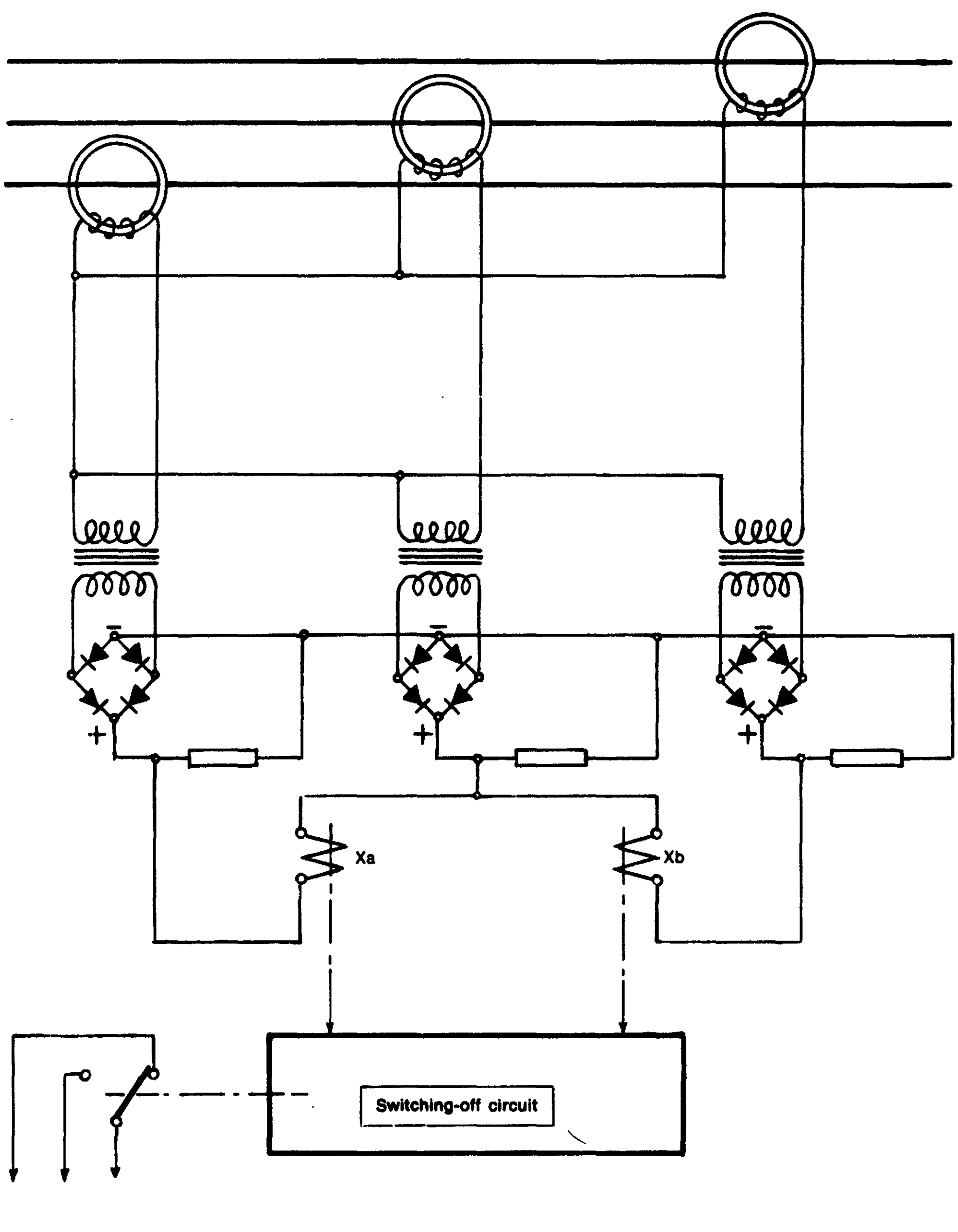
Annex IV

DIAGRAM IX – TYPE CI + BS



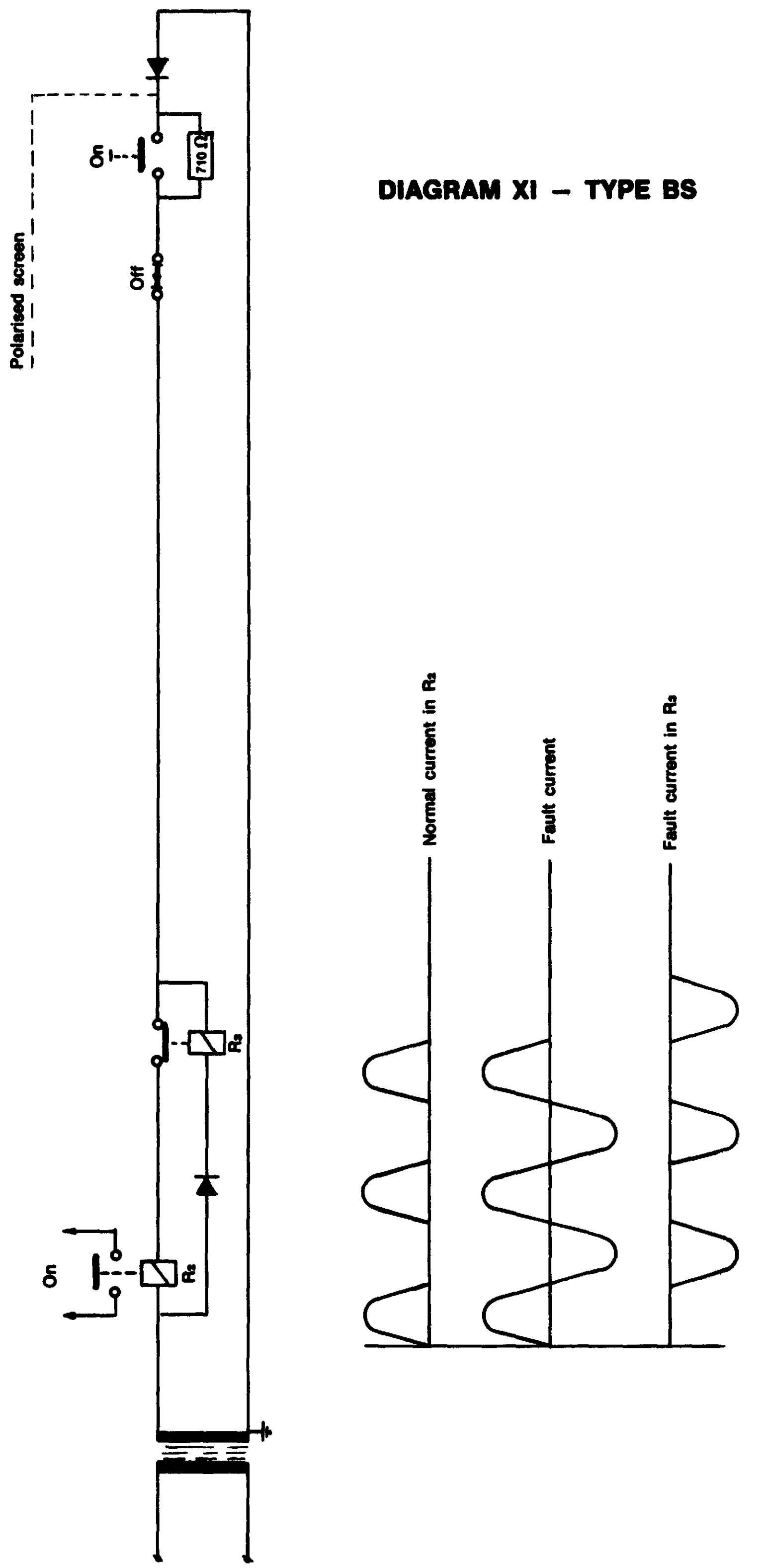
Annex IV

DIAGRAM X – TYPE D DI



Annex IV

DIAGRAM XI – TYPE BS



Annex V

Table showing the main electrical protection equipment for cables supplying mobile machines

Legend to the table showing the main devices for electrical protection of cables supplying mobile machines

The classification and the terms described in the cables and given in the first line of the table correspond to the concepts defined in Annex II.

The protective devices indicated by symbols in the third line of the table are described in Annex IV.

The symbols used in the table have the following meanings :

a) CI = insulation-monitoring device (see Annex IV, page V, 20)

b) BS = safety-blocks (see Annex IV, page V, 21)

c) amp. = amperometric relay

d) R_1 = relay for insulation-monitoring device

e) R_2 = relay for control current

f) R_3 = relay for fault current

g) R_{2+3} = combination of the two relays R_2 + R_3

h) R_4 = double-fault relay (1)

i) CB = core-balance relay (see Annex IV, page V, 19)

j) BU = Back-up relay : amperometric relay with time-lag, which cuts off the supply transformer on the primary side when the core-balance relay on the secondary side does not operate (see Annex IV, page V, 20)

k) CBT = deviced based on amperometric and directional detection of homopolar current (see Annex IV, page V, 20)

l) DDI = impedance-fault detectors (see Annex IV, page V, 23)

If the detection of a fault is simultaneously provided by two relays, the symbols are connected by a + sign. The dash indicates if this point is not applicable, the symbol O indicates that the device does not operate.

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(1) In Germany this double-fault relay is used because up to 1st October 1971 work can go on for 8 hours when there is a fault. This relay R_4 then eliminates the danger of occurrence of a double fault (fault between phase and earth accompanied by a fault between phase and monitoring conductor).

Table showing the main devices for electrical protection of cables supplying mobile machines

Cable type	A.1	A.2	A.3	B.1	B.2, D.2	B.3, D.3	C.1b	C.1a, D.1	C.1a, D.1	C.1a, D.1
Screen(s)	Collective mass conductor	Collective screen to mass	Collective polarised screen (3)	Individual mass conductors	Individual polarised screens (3)	Individual polarised screens (3)	Individual mass conductor & collective polarised screens (3)	Collective mass conductor and individual polarised screens (3)		
Protective device	CI + BS	CI + BS	CI + BS	CI + BS	CI + BS	CI + BS	CB + BS + BU	CI + BS	CI + BS	CI + BS
Diagram (1)	(IV or V) + VI	(IV or V) + VI	(IV or V) + VI	(IV or V) + VI	(IV or V) + VI	(IV or V) + VI	II + XI	VII	VIII	IX
Type of fault										
1) Phase to phase	amp.	amp.	amp.	R_1 + amp.	$R_1 + R_3$ + amp.	$R_1 + R_3$ + amp.	CB + amp.	$R_1 + R_{2+3}$ + amp.	$R_1 + R_{2+3}$ + amp.	$R_1 + R_{2+3}$ + amp.
2) Phase to mass (2)	R_1	R_1	R_1	R_1	$R_1 + R_3$	$R_1 + R_3$	CB + BU	$R_1 + R_{2+3}$	$R_1 + R_{2+3}$	$R_1 + R_{2+3}$
3) Phase to polarised screen(s) or to concentric mass conductor	R_1	R_1	$R_1 + R_3$	R_1	$R_1 + R_3$	$R_1 + R_3$	CB + BU	$R_1 + R_{2+3}$	$R_1 + R_{2+3}$	$R_1 + R_{2+3}$
4) Phase to polarised conductor (3)	$R_1 + R_3$	$R_1 + R_3$	-	$R_1 + R_3$	-	-	CB + BU + R_3	-	$R_1 + R_{2+3}$	-
5) Double fault (4) a) Phase to mass conductor or earthed screen b) Another phase to polarised screen (3)	-	-	-	-	-	-	-	R_4	R_4	-
6) Polarised screen (3) to mass conductor	-	-	R_3	-	R_3	R_3	R_3	R_{2+3}	R_{2+3}	R_{2+3}
7) Polarised conductor (3) to mass conductor	R_3	R_3	-	R_3	-	-	R_3	-	R_{2+3}	-
8) Breakage of polarised conductor (3) or of polarised screen (3) or of mass conductor (breakage of interlocking circuit)	R_2	R_2	R_2	R_2	R_2	R_2	R_2	R_{2+3}	R_{2+3}	R_{2+3}
9) Penetration into the cable of a metallic object connected to mass and touching only the screens	0	0	R_3	0	R_3	R_3	R_3	R_{2+3}	R_{2+3}	R_{2+3}
10) Penetration into the cable of a metallic object insulated from mass and touching only the screens, or possibly also the concentric conductor	0	0	0	0	0	0	R_3	R_{2+3}	R_{2+3}	R_{2+3}
Symmetry of mass conductor	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Application in (name of country)	Belgium	Belgium	France	Germany Belgium	Belgium France	France	Netherlands	Germany	Germany	Italy

(1) See Annex IV.
(2) In France, certain installations are also equipped with CBT and DDI devices (see Annex IV, pages V, 20 and V, 23 respectively). In Germany and Belgium, efforts are made to fit the installations with CBT type devices.
(3) Polarised screen or polarised conductor = screen or conductor under monitoring voltage.
(4) Only for delayed switching-off by CI (see Annex IV, page V, 20) with respect to BS or if the CI device is switched off.

OPINION

ON THE USE UNDERGROUND OF FOAMED URETHANE IN COAL MINES

I. The Working Party's study of this subject has its origin in the desire recorded by the Mines Safety and Health Commission in 1963 that increased attention should be given to the application of polyurethane foam after one of the member countries had successfully sealed the stoppings in a fire area with foamed urethane, and after urethane foam stoppings had been used in two further serious cases - the Mines Inspectorate having issued an exemption in view of the urgency of the case.

The Working Party on Rescue Arrangements, Fire and Underground Combustion has since then followed with great interest the tests carried out by various technical institutions on foamed urethane for use in coal mines.

The Working Party has, in particular, obtained regular reports from Mr. Hausman, Director of the Coördinatiecentrum Reddingswezen van het Kempische Steenkolenbekken, Hasselt, on the research and tests carried out by his Centre. In October 1968, Mr. Hausman presented the Working Party with a report surveying the work carried out at his Centre and the results so far available from tests carried out by other institutes in Community countries and the United Kingdom.

II. The Working Party dealt at length with this report at its meetings on 29.1 and 30.10.1969 and, after carefully examining the matter, came to the following conclusions:

1. Foamed urethane in its hitherto known formulation is a plastic which is outstandingly suitable for sealing operations, works fast and has exceptionally good insulation properties, for which there are a great many uses in mining.

This material is thus particularly suitable as a sealant for use in the erection of stoppings of all kinds and - especially in winning roadways - for the sealing of faces against ventilation losses and undesirable emission of CH_4. Its good insulation properties, as already pointed out, can help to improve the pit atmosphere. The great advantage of urethane plastic in its capacity to shrink to about one thirtieth of its original volume and to form a hard foam which adheres extremely well, although only to a dry base, and is almost gastight. Foamed urethane is a durable material which generally speaking behaves very elastically under the influence of rock movements and pressure. So far no other plastic has been discovered which has such favourable properties.

2. Foamed urethane, in the formulation known to date, consists of a blend of diisocyanates with polyether resins and polyol.

This blend of plastics has severe disadvantages from the point of view of mines safety. It may, if applied in too thick layers, ignite spontaneously because of inadequate dispersal of reaction heat. Some types of polyurethane foam, of course, do not normally lend themselves to rapid fire spread, when they are used on fire or air dams as sealants on a limited area of dam surface. If they are used for a section of cylindrical surface on the other hand there is a danger of rapid fire propagation on the surface (tunnel effect), which may lead to an extraordinarily fierce fire.

Experience has shown that in the very fierce combustion of foamed urethane the combustion gases show only very little oxygen content. This may under certain circumstances lead to loss of life, even with the use of filter-type self-rescuers. The fire risk inherent in foamed urethane may of course be reduced by various devices, for example by coating with a flame retardant material or by applying a plaster layer, provided the section of roadway thus treated cannot be reached by a fierce fire. Some of these coatings of course lose their effectiveness over longer periods by flaking off under the effects of rock pressure and as a result of prolonged exposure to flame. Also they can only be applied on one side, namely the accessible side of the stopping.

A further disadvantage is the low electrical conductivity of foamed urethane, due to which there is a possibility of electrostatic build-up and hence of sparks being produced which may lead to combustion. This disadvantage is, however, neutralised by applying a plaster coating to the entire surface.

3. Consideration of the advantages and disadvantages of using foamed urethane leads to the conclusion that this plastic in its hitherto known composition cannot be declared suitable for use in mines without reservation.

The favourable sealing properties, however, indicate that it would be inadvisable in principle to reject its use in mining.

Ways and means should therefore be found of altering the composition in such a way that its positive advantages are to a large extent preserved while the disadvantages at present inherent in its use are considerably lessened.

The improvements to be aimed at in any development of foamed urethane or other comparable plastic - with the object of creating the conditions which would make possible its unrestricted use in underground mining - would need to be concerned with the following properties:

3.1. The plastic and the devices required for its application must be designed in such a way that they can be used and handled at any time by colliery personnel and do not require recourse to specialist firms each time they are used.

3.2. It should be possible to apply the plastic in a single operation, even on damp surfaces.

3.3. The plastic should, after its application, not be subject to any dangerous build-up of electrostatic charges.

3.4. The composition of the compound must not show any deficiency with regard to its hygienic properties.

3.5. The foam, once it has set, must not be easily inflammable and, if ignited, must not continue to burn even on a cylindrical surface (tunnel effect) without application of heat. The individual constituents must also not be slow to ignite.

3.6. In the event of fire it should not be possible for the use of filter-type self-rescuers, to be restricted through lack of oxygen or through the products of decomposition of the plastic.

4. The use of polyurethane foam in its hitherto known composition in mine workings varies from one country to another. Nowhere it is subject to comprehensive regulations, however.

5. The Mines Safety and Health Commission considers it desirable that the producers of the foamed urethane plastic should further develop the compound at present available in such a way that, while retaining unchanged the positive properties which it now has, it satisfies the requirements set out under 3 above.

The coal mining industry of the countries of the Community is keenly interested in this continued development of either polyurethane or a comparable plastic in view of the improvement in mine safety which this may bring about.

A NEW MEASUREMENT AND TESTING METHOD FOR ROPES USED IN SHAFTS AND ROADWAY-HAULAGE SYSTEMS AND FOR GUIDES IN SHAFT- AND ROADWAY HAULAGE INSTALLATIONS

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1. Introduction

The constantly increasing demands placed upon haulage ropes, especially as a result of the concentration of collieries, and the manifold and to some extent very high, demands placed on the haulage cables used in roadway-haulage installations frequently lead to premature failure of the ropes. It is therefore necessary to institute exhaustive investigations into the factors which affect the working life and functional capacity of these ropes.

At the Seilprüfstelle, Institut für Fördertechnik und Werkstoffprüfung der WBK Bochum (Rope-testing Station) a selection was made from the multiplicity of factors which affects the resistance in time of the ropes, to concentrate on the important categories of kinetic stresses which have not yet been included in the methods of computation used in the selection of the type of rope and the dimensions of ropes. In addition, diagrammatic representations were set up of the functional relationships between the principal parameters which affect the working life of ropes, from which it is possible to predict the way in which the rope will stand up to static, heaving and heaving/bending stresses as well as to the transmission of forces between the rope and the drive pulley, together with other factors.

The prerequisite condition for this exhaustive testing of the suitability of the ropes was the establishment of new rapid testing processes and measuring methods to determine the capacity of the rope to resist the stresses imposed, so that on the one hand it was possible to obtain quantitative data on the important individual loading factors and on the other hand possible to apply continuous checks of the test results obtained.

The effects of the state of the guides in main and staple shafts and the quality of the rope guides in roadway-haulage installations on the working life of the ropes was also taken into account.

2. Winding ropes - Selection on the basis of static and kinetic factors.

In a shaft-winding installation the winding ropes and the braking system are the elements which must receive particular attention for reasons of safety. In installations with drive pulleys, factors of equal importance are the lining of the drive pulley and the lubrication of the rope, which are intended to ensure transmission of the forces from the drive pulley to the rope and vice versa without any slip. Fig. 1 gives a summary view of the multiplicity of the other factors which must work together harmoniously in a high-capacity, safe winding installation. This classifies the essential factors which affect the working life of a rope. These factors must be given maximum possible attention in selecting ropes which will fulfill most efficiently the requirements placed upon them.

2.1. The important group of kinetic stresses in a winding installation, in particular the heaving and heaving/bending stresses on winding ropes, will be more closely examined in what follows.

The effect of changes in the stress in a winding rope is a factor which has only recently been given the attention which it deserves. The range of those rope stresses which act upon a given cross-section of rope during a wind must not be allowed to exceed a maximum value, if the danger of a premature failure of the rope is to be eliminated. This observation is true not only for winding ropes but also for any type of rope which is subjected to dynamic loads, such as e.g. bridge, dredger, crane and cable-railway ropes, etc.

2.1.1. The range of quasi-static heaving stresses is the difference in stress which occurs in a rope above the attachment point, when the empty conveyance in the shaft landing is loaded and then raised to pit-bank level. In this operation, there occurs - in addition to the increase in stress due to the payload being carried - an increase in stress caused by the rising weight of the rope raised during the wind, Fig. 2.

The range of quasi-static heaving stresses is increased or changed by the accelerations and decelerations which occur during the wind. The range is in this case a dynamic magnitude, Fig. 3.

In addition to the quasi-static and dynamic heaving stresses (tensile stresses) in the ropes in a winding installation in a shaft, geometric bending stresses occur as the rope runs over the drive and guide pulleys, and these become added as normal stresses to the tensile-heaving stresses. The total of these two types of normal stress will be termed the heaving/bending stress and is the difference between the maximum and minimum values of the range of heaving/bending stress. As in the case of pure heaving stresses, we distinguish between quasi-static and dynamic values.

2.1.2. In addition to the heaving/bending stresses, there is also an additional load, which is caused by the transmission of forces between the rope and the driving pulley. This additional load consists of displacements and twistings, which are inter alia produced in the whole rope by transmission of the frictional force from the bearing surface in the lining of the rope pulley. Since the stresses caused in the rope as a result of these loads are not pure normal stresses, they must be separately treated in considering the load picture.

The heaving/bending loads occurring in the course of force transmission occasion the heaviest loads on the rope in the zones of acceleration and deceleration, a fact which is clearly shown in Fig. 4 by the concentrations of broken wires in these zones. Consequently, this type of loading must receive special consideration in the test method.

Figs. 2 and 3 show the types of stress just described, using the example of a tower-mounted winding installation with a deflector pulley. The quasi-static and dynamic ranges are indicated by appropriate symbols of vibration. It can be clearly seen that the ranges of the dynamic heaving/bending stresses can reach high values during acceleration.

2.1.3. In Figs. 2 and 3, the calculations carried out apply only to stresses for uniform running and for accelerated movement. To get a picture of the trend of the heaving/bending load during a whole wind, Fig. 5 shows the average tensile stresses (heaving stresses) of the ropes in a tower-mounted four-rope winding installation without deflector pulleys in five phases of the winding operation.

In this presentation, in order to simplify the recognition of the ranges in the vicinity of the driving pulley during various phases of acceleration and deceleration, the superimposed geometrical bending stresses - as well as the supplementary stresses occurring with power transmission - have been left out.

Whereas the tensile stresses in the rope increase with increasing acceleration, they fall off with increasing deceleration, pass through a value of zero and reverse their direction, then reaching at a value of $a = -3.0$ m/s^2 the value which corresponds approximately to the range at the driving pulley before starting. In the zone of deceleration the load on the rope is thus lower then in the zone of acceleration. Since, however, with a twinstrand winding system the zones of acceleration and deceleration alternate, the loading on the rope is approximately equal in these zones, as can be seen from the distribution of frequency of breaks in the wires (Fig. 4).

The average value of the ranges of variation in main shaft winding installations in the Ruhr is at present around 15.3 kp/mm^2, the peak value reaching 18.0 kp/mm^2. These stresses, which occur in association with the quasi-static ranges (and are simple to determine) are only comparative values against the very much higher dynamic ranges in the vicinity of the driving and deflector pulleys.

2.2. The types of stress described above, which occur in mining ropes, can be simulated in a new dynamic rapid testing method developed by the Seilprüfstelle der WBK, in such a way that precise determination of the effects on rope life of the following factors can be made:

a) heaving stresses

b) heaving/bending stresses without transmission of forces and

c) heaving/bending stresses with transmission of forces.

Changes in the pulley linings, the lubrication of the rope, the shape of the pulley grooves etc., made while maintaining all other test conditions constant, can be used to determine the influence of those factors which have an effect on the working life of the ropes.

The static measurement and testing methods (technical tests) for wire ropes for most types of application have been developed both on the national and the international level to such a point that they still require only small changes to bring them up to date with latest developments. On the other hand, the kinetic measurement and testing methods for wire ropes have been strongly developed only in certain directions. In most of the cases requiring investigation of the whole rope, the tests are of long duration and involve assessing various part zones of the rope loading. There is therefore an urgent need to subject the kinetic loadings - which are at the very least of equal importance and in many cases of overriding importance for the working life of the rope - to analysis in a system which is capable of giving rapid information about the interactions of the various individual parameters.

The new dynamic rapid testing method uses a pulsator device attached to one end of the rope, together with a three-roller unit which undergoes translatory movement within the clamped ends. The drives for the pulsation device and the three-roller unit are independent, so that no limits of any importance for the tests are imposed on the combinations of frequencies (Fig. 6).

A magneto-inductive examination of the state of the rope in the straight and bent sections along its length serves, together with a device for measuring stretch, to give continuous supervision of the test process. Facility for automatic switching-off at pre-determined values of stretch ensures reliable measurement values at the end of the test. Careful temperature monitoring keeps the tests within conditions which closely resemble practice.

The advantage of the dynamic rapid test device, which can be set up either horizontally or vertically, consists in:

1) the possibility of obtaining - during and after a test operation - the characteristic curve of reduction in the breaking strength of the rope for several types of loading and stages;

2) the adaptability of the device to special cases of loading, e.g. for main- and staple-shaft ropes, hauling ropes for cable railways, scraper ropes, dredger ropes, roadway-haulage ropes, etc.

3) the large amount of information available from the results of the test for an outlay which is low in comparison with what was possible hitherto.

In Fig. 7 the possibilities of this method are set out, using the three-roller device together with magneto-inductive testing, in schematic form. The factors which affect the working life of the rope are classified in groups. The geometrical magnitudes of a winding installation, such as pulley diameter, angle of deflection of the rope, shape of the pulley groove etc. are simulated in the three-roller device. We distinguish between two systems of three-roller device. With system 1 (Fig. 8) the pulley diameters are different. In such cases the section of rope tested is rolled only once over the pulley at one stroke. With system 2 (Fig. 9) the rollers are similar with respect to groove shape, diameter and material. In contrast to system 1, in this instance the sections of rope are rolled twice or three times over the pulley during a stroke.

System 1 serves for the investigation of the effects of the various curvatures of the ropes under static and kinetic loadings on the working life of the rope.

System 2 with similar rollers, resulting in multiple rolling of single sections of the rope, makes it possible to determine the reduction in the breaking strength of the rope on a single test piece.

Since the test rope - clamped firmly at one end and pulsated at the other - also contains sections which have not been rolled over, tests on individual wires will give a complete curve of reduction in breaking strength of the rope. This method thus offers the possibility of studying the state of the rope for a given predetermined range in relationship to alternate bending. The varying degrees of stretch occurring within the rope give, in the individual sections of the rope, various temperatures caused by the loading due to rolling over. Since the three-roller device produces alternate bending in zones of low and high rope stretch, the effect of rope temperature and rope stretch on the working life of the rope can be determined simultaneously.

Rope breakage in the zone which is rolled over three times during one stroke is a further measuring point in the general diagram, which gives the trend of the breaking strength of the rope - in relationship with the frequency of rolling over (alternate bending) where there is

a) a rise in the heaving stress or

b) an intensification of the bending of the rope.

This type of representation makes it possible to provide in various forms

1) determination of the zones in which give satisfactory results and

2) comparisons between the various types of rope design under the sets of loading conditions which have to be studied.

If one of the rollers is driven or braked (Fig. 10), the loading on the rope with transmission of forces can be simulated. This makes it possible to study on one test rope the effect of

heaving stresses,

heaving/bending stresses without transmission of forces and

heaving/bending stresses with transmission of forces.

The multiplicity of results obtainable from a single sample, together with the great deal of information which can be obtained, makes the method a research and testing tool which is very economical, and which makes it possible to carry out investigations in the broad framework of static, kinetic and geometrical loadings on the rope on a basis which has not been previously developed.

2.3. Diagramatic system for the assessment of the results of the new dynamic rapid testing method of the Seilprüfstelle der WBK (Fig. 11).

It is advisable to investigate in the first place one design of rope under various dynamic and geometrical test conditions and to plot the results in a diagram with the combination of angles of deflection on the ordinate and the alternations of bending on the abscissa, the heaving stress being the parameter (diagram group I/1), Fig. 12. Following this, it is necessary to select the type of diagram which uses the heaving stress as the ordinate and the combination of angles of deflection the parameter (diagram group II/1), Fig. 13. These two groups of diagrams make it possible to get a good picture of the dynamic and geometrical zones in which the rope design being tested will fail. The rope designs shown by this method to be suitable are compared with one another, making use of the forms of representation I/2 and II/2.

These two groups of diagrams, which have the design of the rope as the parameter, make it possible to select the right rope clearly (Fig. 14 and 15).

3. Comparison between the newly-obtained test results and operational assessment of the ropes by means of the improved Bochum formula for rope work in main and staple shafts.

In order to be able to carry out continuous comparison results obtained and the new measuring and testing method with those obtained in practical operation, statistical control methods were worked out for those cases where the outlay has prevented the development of comparative testing facilities based on actual operation; these statistical checks provide continuous assessment of the difference between the test results and the way in which the ropes stand up to use.

In the improved Bochum rope work formula - used to determine the work done by the rope - appropriate attention is paid to the static, kinetic, geometrical and technical factors.

The expression W for the work done is multiplied by a loading factor $K_{H(B)}$, this factor allowing for the special conditions in a main or staple-shaft winding installation (Fig. 16).

The factor $K_{H(B)}$ comprises data dependent on the installation and on the operational characteristics, and which have an effect on the working life of the rope.

If $K_{H(B)} > 1$, this signifies that the total of factors dependent on the installation exerts less favourable effects on the working life of the rope than is the case over the average of all Ruhr pits in main- or staple-shaft winding installations.

If $K_{H(B)} < 1$, the total of all the factors affecting the working life of the rope is better than the Ruhr average.

The first bracketed expression in the square brackets for $K_{H(B)}$ reflects the loading on the rope under the transmission of forces on the driving pulley and the effect of acceleration, deceleration and abrupt loadings during winding. The acceleration factor a and the factors s and b are taken from tables prepared by the Seilprüfstelle der WBK. These tables are constantly checked.

The second expression in brackets is an index of the bending stress on the rope in the winding installation.

The term s is an empirical factor allowing for the number of rope and deflector pulleys and their D/d ratio.

The third expression in brackets reflects the surface area pressure between the rope and the lining in the pulley groove on the driving pulley in relation to the average value for Ruhr pits.

The factor b indicates the embedment of the rope, i.e. the shape of the rope groove and the material in the groove in the driving pulley and rope pulleys.

If factors a and s are not known, they are replaced by the figure 1.

Comparison of the results obtained with the new dynamic rapid testing method with those obtained from the formula for the assessment of the rope in practical operation makes it possible to check the factors a, s and b. If proper correction of the factors is applied the difference between predicted and actual performance in operation will be reduced.

4. New measurement method for shafts and shaft guides.

Measurement methods have been developed in order to throw light on the relationships between the state of shaft and rope guides and the additional forces caused thereby; these methods indicate the relation between faults and the forces which they produce. The knowledge of this additional forces is required, on the one hand, as an important factor in the dimensioning of the shaft guides and, on the other hand, to provide an accurate estimate of the loadings which are superimposed on the basic stresses in the winding rope.

A new combined measurement device, developed by the Seilprüfstelle der WBK, not only saves time but also yields measurement results which give more information than was the case with methods used hitherto. The device is made up of several individual basic measurement appliances and can be used in first, second or third order combinations (Fig. 17).

These new measurement methods can firstly be used to determine the forces arising between the conveyances and the guides and secondly, and simultaneously, to indicate the faulty guide joints and measure the wear on the guides at full or reduced winding speed and at full load. At lower speeds, the geometrical characteristics of the guides and any tilt which they may have undergone can be established. In addition, with the conveyances stationary, it is possible using two laser alignment devices with suitable measuring tables connected with geometrical measuring bodies, to determine the position in space of the guides and other shaft furniture. By the use of accelerometers or force measurements in the suspension gear, the additional forces acting on the winding ropes are determined and their dependence on the geometrical dimensions of the shaft guides established.

Fig. 18 shows a combined measuring device of this type, although there is no indication of the accelerometer, which is set up on the roof of the conveyance or on any of the decks in the conveyance.

Fig. 19 shows one half of the measurement device with measuring table and laser alignment device.

5. Classification of rope-driven roadway haulages and the loading on the haulage ropes.

5.1. Difficulties in determining the time at which a rope should be removed; the purpose of a rope atlas.

The multiplicity of factors which affect the working life of a rope - e.g. by reason of the different designs of roadway haulage system - makes the determination of the proper time to discard the rope, a task which cannot be carried out without a knowledge of the behaviour of the rope under the action of dynamic and geometrical parameters.

A rope atlas repaired by the Seilprüfstelle der WBK for rope-driven roadway-haulage conveyances is therefore not capable of dealing fully with all the questions which arise in connection with establishing the correct point in time to discard a rope. It should rather be considered as an aid for the rope-tester and for all persons responsible for the construction and operation of such types of roadway-haulage installation.

Since it is possible in only a small number of cases where tests have to be carried out to determine by the naked eye, the permissible falling-off in breaking strength, it becomes obligatory to have available completely satisfactory information regarding the properties of the ropes under the types of loading to which they are subjected. This information is provided by the rope atlas on the basis of systems of diagrams representing the falling-off in breaking strength under the effect of major influencing factors, together with illustrations of the different states of ropes, corresponding to the diagrams. Moreover, the continual development of transport systems makes it necessary to carry out continuous checking of the basic information material in assessing the discarding time for haulage ropes for roadway haulage systems, supplementing this information, or replacing it, by new data appropriate to the changes which have occurred.

In preparing the rope atlas, particular attention was paid to working out the characteristic curves of reduction in breaking strength for the various designs of rope to be studied, these curves showing the beginning and the trend of failure under various types of loading. This seemed to be necessary, since it is often impossible to recognise the permissible 15 % limit of reduction in the breaking strength, so that without such an aid it is impossible to assess the risk level accurately.

In spite of the assistance given by the rope atlas, the rope-tester is in a very large number of cases overburdened, since heavy dirtying of the rope surface, very great lengths of rope (in individual cases over 10 km), various running times of different section of the rope with varying zones of loading, worn places on the rope etc. make the work of testing far more difficult than usual. In this connection, it is, inter alia, necessary to supplement the tests by magneto-inductive rope-testing methods.

The test results recorded in the rope atlas were obtained from several independent testing methods, so that any effect due to a particular process is recognised and can be eliminated (Figs. 20 and 21). A further guarantee of the results is obtained from tests on rope-testing beds, installed in the basement at the Seilprüfstelle der WBK in the testing range for rope-driven roadway-haulage conveyances (Fig. 22).

In assessing the state of the rope it is necessary, in order to estimate how much further use can be safely given to the rope, to have a knowledge of the degree of risk in the installation. With a level haulage installation, different criteria with respect to the frequency of rope checks can be applied from those applied to haulage installations in inclined roadways, and in which the position and magnitude of the inclinations can give rise to dangerous situations in the event of a rope breaking.

The assessment index for the rope loading and the degree of risk give the "degree of difficulty" of the complete installation; this factor will be explained in what follows.

5.2. Classification of rope-driven roadway-haulage installations from the viewpoint of the loading of the haulage ropes.

In order to obtain with simple means full information regarding the degree of difficulty and the operational condition of a rope-driven roadway-haulage installation, it is necessary - because of the changes in the management of the roadway, e.g. changing the track of the haulage installation, effects of rock pressure etc. - to use other measuring methods than those applied in fixed shaft installations.

The rope constitutes the central point of these considerations, being subjected to risk and having a time-affected strength. By reason of the limited space available, the roadway management conditions (which are often difficult) and the varying states of the rails used to brake the conveyances in the event of a rope break, it is at the present time still difficult to construct brakes which are reliable and not excessively harsh in operation. Consequently, in unfavourable track conditions, the safety of the installation is particularly dependent, in the first place, on the reliability of the drive rope and only in second place on the braking devices used.

The loading of the haulage rope depends not only on the payload and dead weight to be transported but also on the length and type of the roadway and on the pre-tension. Curves, rising or falling sections of road, the degree of precision of laying the rail tracks and rope guides, the type of drive, the pre-tensioning of the rope at the return pulleys, the method of operation etc. cause the basis stress in the rope to be overlaid by heaving stresses which cause additional kinetic loading of the rope. These heaving forces - together with geometrical factors, such as e.g. the deflection angles of varying magnitude, the different diameters of drive pulleys and rollers in the rope-guide and drive systems - lead to marked differences in the working life of the rope. In addition to these conditions, governed by the designs of the plant and the operating circumstances, and all of which affect the rope's working life, there is also the suitability of the design of the rope for these special operating conditions.

In order to get more detailed information regarding the magnitude of the differences in heaving force, the Seilprüfstelle der WBK developed electrical and mechanical measuring devices and methods. With stress measuring and classifying devices on the drive machine, on the tensioning trolley, on the connection between the tensioning trolley and the transporter attachments, at the return stations, on the support attachments, and at particular points along the drive rope, the force conditions in the haulage system were recorded, to obtain data about the functional relationship between the individual types of loading in the roadway-haulage system (Figs. 23 and 24).

5.2.1. Loading of the haulage ropes by dynamic and geometrical factors (assessment.

The classification of heaving stresses of the haulage ropes should preferably be expressed in terms of 15 % of the breaking strength of the rope (basic stress).

The rope safety prescribed by the Mines Inspectorate in respect of rope-driven roadway-haulage installations is 6-fold for materials transport, and as a rule 9.5-fold for man-riding. For materials transport the maximum permissible stress of the rope would therefore be approximately 17 % of the breaking strength of the rope.

The various stresses occurring during a haul are converted into kinetic loading figures, and the geometrical dimensions of the rope drive and the rope guides into geometrical loading figures, by means of tables (Fig. 25 and 26). For purposes of checking, the two loading figures are transformed - by means of a table prepared by the Seilprüfstelle der WBK - into kinetic geometrical loading figures α_k and α_g.

5.2.2. Calculation of the work done by the rope.

The classification magnitude K_{Str} for rope-driven roadway-haulage installation is developed from the kinetic and geometrical loading factors α_k and α_g. The classification magnitude K_{Str} is the component of the new rope work formula for roadway-haulage installations which takes into account the special conditions with respect to rope loading. The rope work formula itself consists of the work term W related to 1 kp of rope, this expression being multiplied by the classification magnitude K_{Str} (Fig. 27). The conversion of the dimensionless classification magnitude K_{Str} into rope loading groups is carried out on the basis of the values in the table in Fig. 28. The haulage installations are here classified in five permissible loading groups I_K - V_K and a non-permissible range $\geq V_K$. A value of K_{Str} greater than 1.1 indicates that the track causes rope consumption above the average, while the value for K_{Str} below 0.9 indicates a value below average. With one and the same design of rope it can therefore be expected in the second case that the rope will have a longer working life - i.e. do more haulage work than in the first instance.

The degree of danger in the event of a rope break is also classified in the table in Fig. 28 into five permissible groups I_D - V_D and a non-permissible zone $\geq V_D$. The explanatory loads to the individual groups are shown in the table in Fig. 28.

The average of the class index of the "rope loading group" and the class index "degree of risk in the event of rope break" gives the index of the degree of difficulty of the installation

$$\text{e.g. } \frac{II_K + V_D}{2} = \text{index of degree of difficulty} \quad \textcircled{3.5.}$$

6. Rope state reports showing falling-off in rope strength for the assessment of the behaviour of ropes under the effect of different factors (standard sheets for ropes used in roadway-haulage installations).

6.1. As in the case of main- and staple-shaft ropes, rope tests are carried out to determine the working life of suitability of the ropes in testing-machine using pulsation and a three-roller apparatus (with equal or different roller diameters), this latter device being given an upwards and downwards translatory movement (Fig. 28). The results of these tests are recorded in standard sheets which show the most important test data. In addition to the identification in the top-right-hand corner of the sheet, the test data and results are entered in the appropriate boxes below the rope state pictures.

Explanation of the identification:

First row (from left to right)

a) roman figure	= Identification number of the rope design
b) capital roman letter	= Identification letter for the rope manufacturer
c) arabic number	= Angle α of rope deflection on the outer rollers with equal roller diameter
d) arabic number	= Amplitude of vibration produced by the pulsator δ_a (kgf/mm2)

Second row (from left to right)

Diameter of the upper, middle and lower rollers in the bottom of the groove.

The photographs show the sections of rope after the tests

a) Top left illustration:

Section of rope subjected only to dynamic tests in the testing machine (scale 1.5 : 1)

b) Bottom left-hand illustrations:

Cross-section of the rope samples (scale 3.0 : 1)

c) The central illustrations:

A section of the rope rolled over once per stroke of the three-roller apparatus (1 alternate bending per stroke), (scale of upper illustration: 1.5 : 1, scale of lower illustration: 2.7 : 1)

d) Right-hand illustrations:

Section of rope rolled twice per stroke of the three-roller apparatus (2 alternate bendings per stroke), (scale of upper illustration: 1.5 : 1, scale of lower illustration: 2.7 : 1).

The boxes below the three groups of illustrations contain the loading data and the test results of the sections of rope illustrated above. The information given in each case comprises:

Top left	: Maximum and minimum force on the rope in kp
Top right	: Minimum and maximum stress in the rope in kp/mm^2
Top centre	: Measured maximum rope temperature in °C
Top right	: Geometric reflections of the rope on the rollers in ^{g} (degrees on the 400° circle)

Right centre : Number of corresponding alternate bendings produced by the three-roller apparatus

Bottom right : Number of corresponding changes of loading between minimum and maximum force.

The diagram given below shows the falling-off in rope force in relation to the alternate bendings (numbers of times the rope is rolled over in the three-roller apparatus). The rope force of each section of rope is calculated from the tensile tests of the individual wires according to the geometrical and dynamic loadings acting.

The standard sheets can also be prepared as transparent photocopies, so that by superimposition they can be used to compare the different characteristic curves of breaking strength to provide a comparison of the effects of various degrees of loading and types of rope designed.

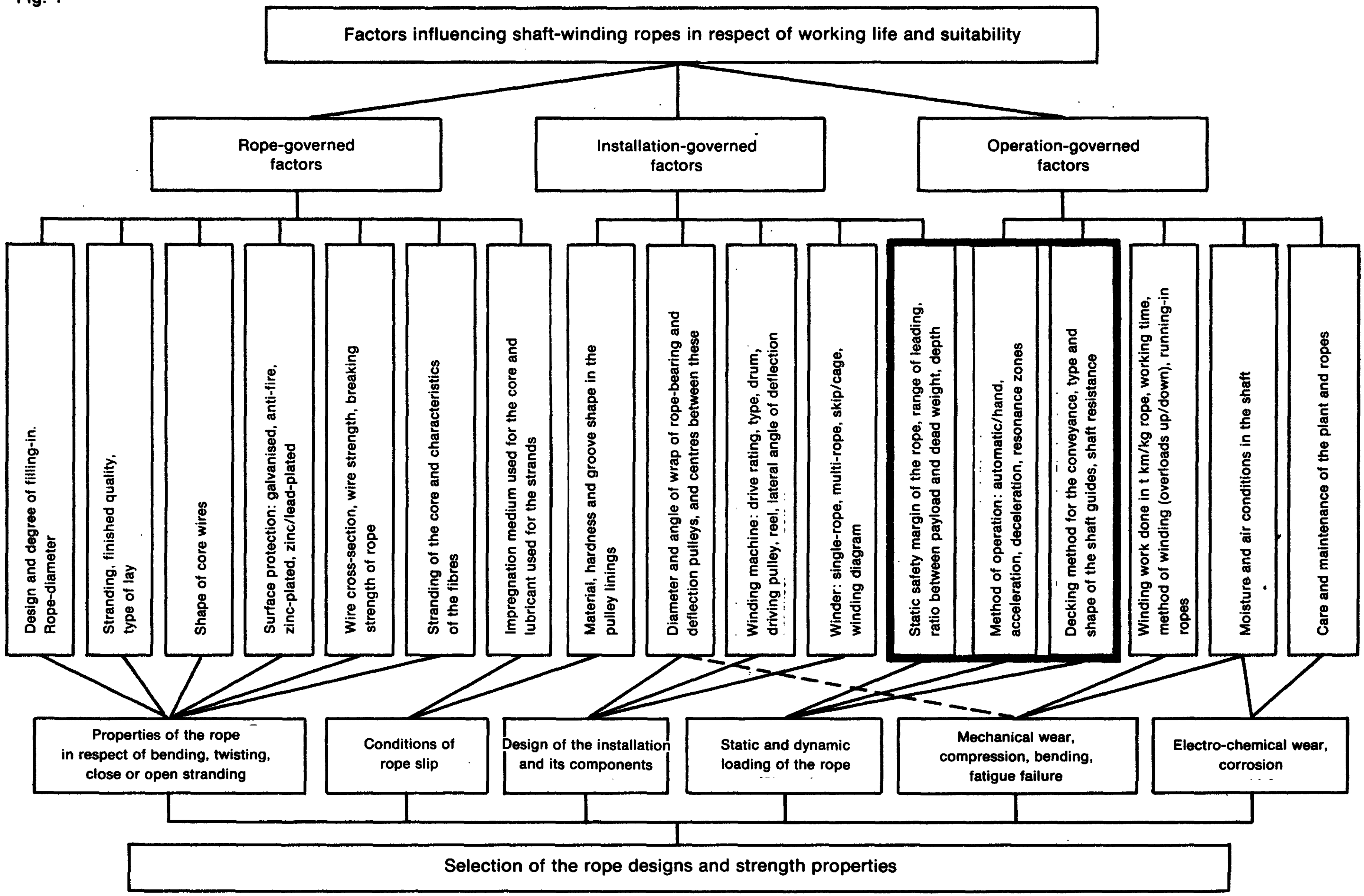
The standard sheets illustrated in Figs. 29 to 34 represent a choice from some of which it will be clearly seen how difficult it is to determine the point in time at which a rope should be discarded, in the case of ropes with high kinetic and geometrical loadings. The other group shows illustrations of the state of the rope under low stresses. In this case the assessment of the correct time for discarding a rope is easier, and in addition these ropes can still absorb a fairly large number of alternate bendings before breaking.

7. Conclusion

Only after a long period of investigation will it be possible to define the limits of the new testing process with respect to its expression of the operating conditions and the clear separation of the various factors affecting the working life of the rope. The investigations carried out to date at the Seilprüfstelle der WBK constitute a step along the road to a rapid and fully informative method of dynamic rope testing. The possibility of effectuating a rapid analysis of the factors taking effect offers a new aid in the assessment of ropes and the selection of ropes. It is particularly important for the success of the new testing method to adapt the methods used for checking the operational suitability of ropes to the testing method in such a way that the differences between prediction and operational behaviour are clarified and reduced. Observation of the trend of these differences make it possible to improve the testing and checking methods, so leading to the development of functionally satisfactory rope designs.

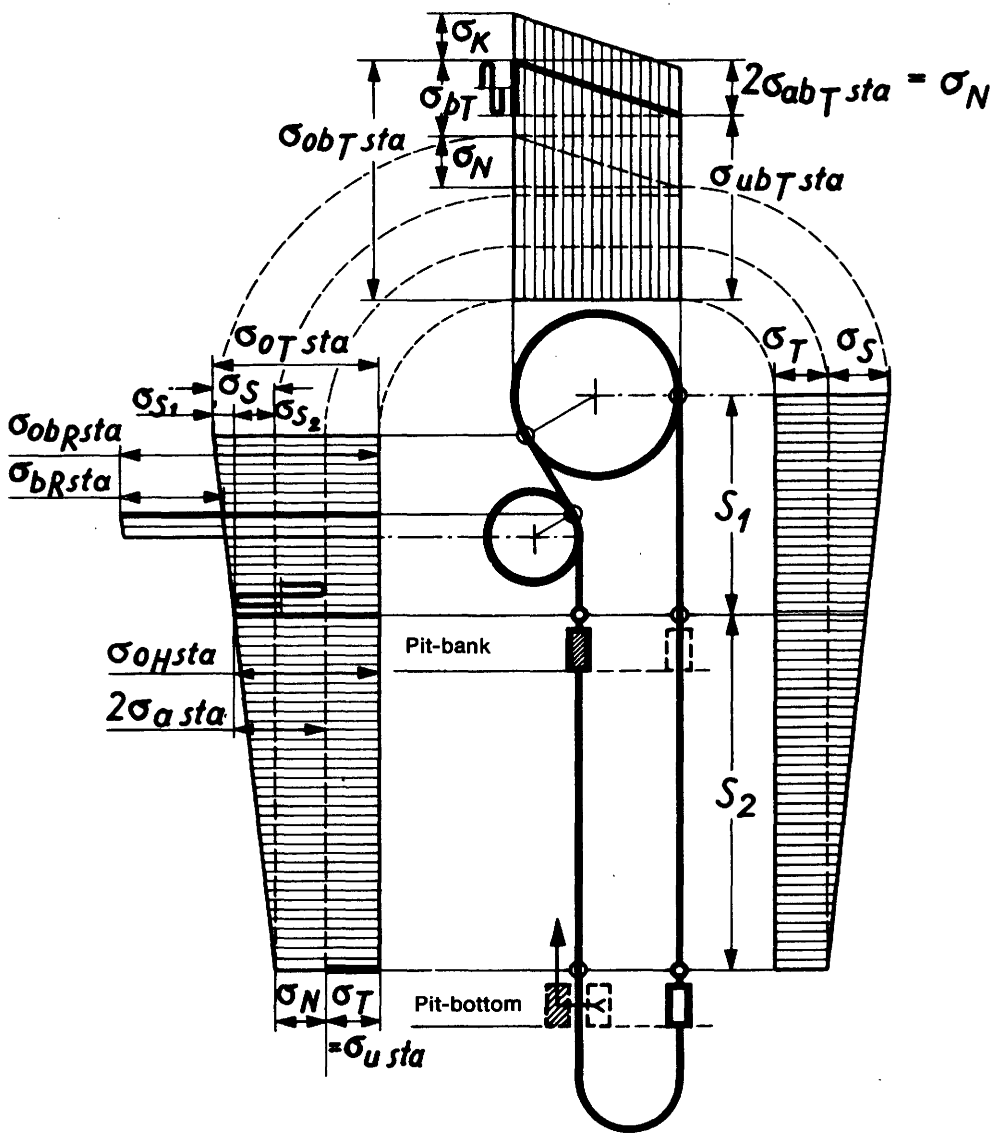
Fig. 1

Diagram showing the interrelationship of the characteristics of the winding ropes and the winding installations in which they are used



Static conditions as rope stress with a tower-mounted driving pulley system with a deflector pulley

Fig. 2



σ_T = Stress caused by dead weight

σ_N = Stress caused by payload

$\sigma_S = \sigma_{S_1} + \sigma_{S_2}$ = Stress due to rope weight

σ_{bT} = Geometrical bending stress at driving pulley

σ_{bR} = Geometrical bending stress at deflection points

σ_K = Additional stress on transmission of sources from driving pulley to rope

$\sigma_{u\,sta}$ = Minimum value of the static heaving stress above the capel (pit bottom)

$\sigma_{oT\,sta}$ = Static heaving stress before running off the driving pulley

$\sigma_{oH\,sta}$ = Maximum value of the heaving stress above the capel (pit-bank)

$2\sigma_{a\,sta}$ = Static range above the capel

$\sigma_{obT\,sta}$ = Maximum value of the static heaving/bending stress in running off the driving pulley

$\sigma_{ubT\,sta}$ = Minimum value of the static heaving/bending stress in running off the driving pulley

$$\sigma_{ubT\,sta} = \sigma_{obT\,sta} - \sigma_N$$

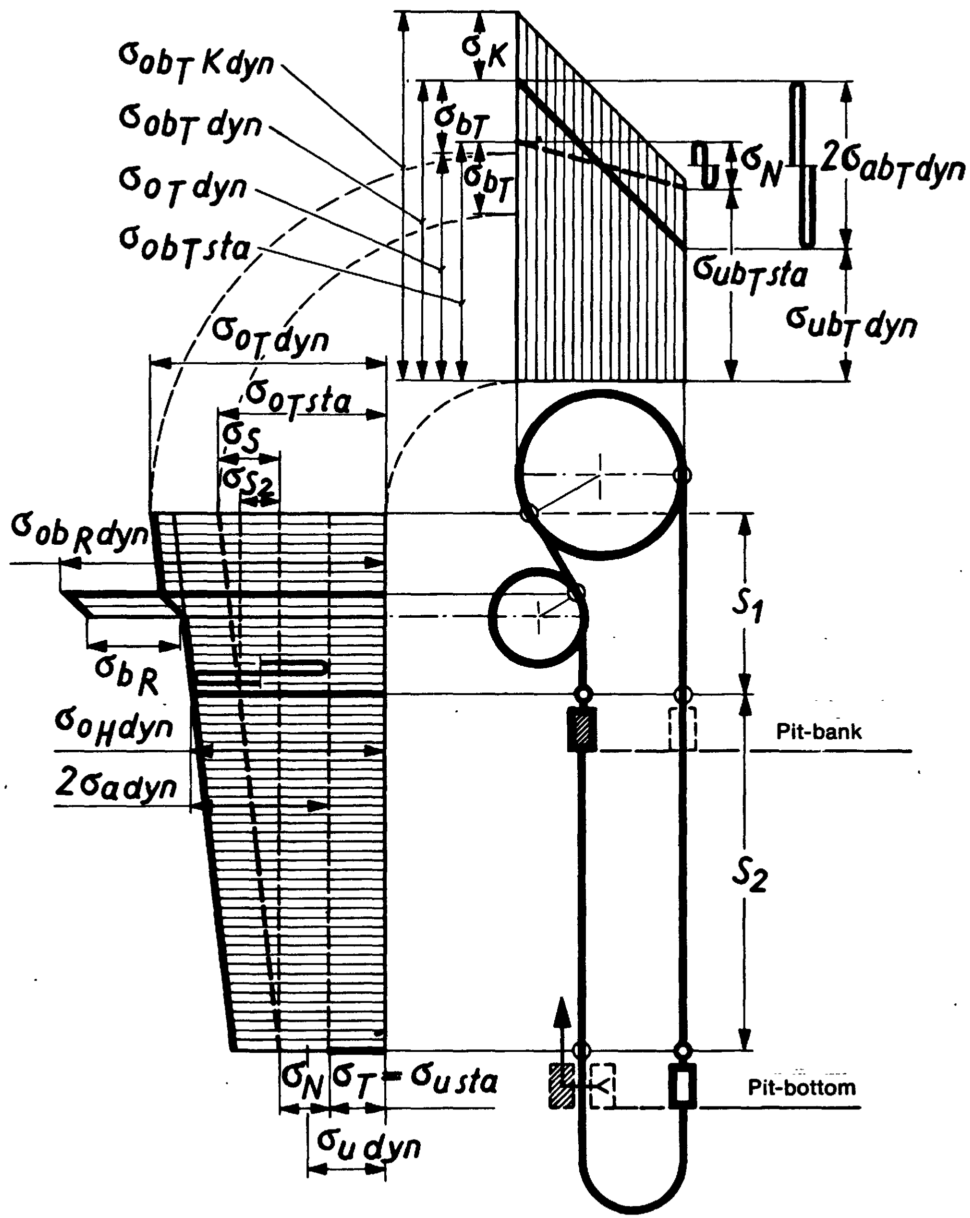
$2\sigma_{abT\,sta}$ = Static range in the vicinity of the driving pulley $2\,\sigma_{abT\,sta} = \sigma_N$

$\sigma_{obR\,sta}$ = Maximum value of heaving/bending stress in the vicinity of the deflector pulley

sta = Sta = Quasi static

Static and dynamic conditions as rope stress with a towermounted driving pulley system with a deflector pulley

Fig. 3



$\sigma_{u\,dyn}$ = Minimum value of the dynamic heaving stress above the conveyance capel (pit bank) (Only during starting-up empty conveyance)

$\sigma_{oT\,dyn}$ = Dynamic heaving stress *before* running off the driving pulley

$\sigma_{oH\,dyn}$ = Maximum value of dynamic heaving stress above the capel (pit bank)

$2\sigma_{a\,dyn}$ = Dynamic range above the capel with a minimum value of

$$\sigma_{u\,sta} = \sigma_T$$

$\sigma_{obT\,dyn}$ = Maximum value of dynamic heaving/bending stress when running off the driving pulleys

$\sigma_{ubT\,dyn}$ = Minimum value of the dynamic heaving/ bending stress when running off the driving pulleys

$2\sigma_{abT\,dyn}$ = Dynamic range in the vicinity of the driving pulley

$$\sigma_{ubT\,K\,dyn} = \sigma_{ubT\,dyn} + \sigma_K$$

$$\sigma_{obT\,K\,dyn} = \sigma_{obT\,dyn} + \sigma_K$$

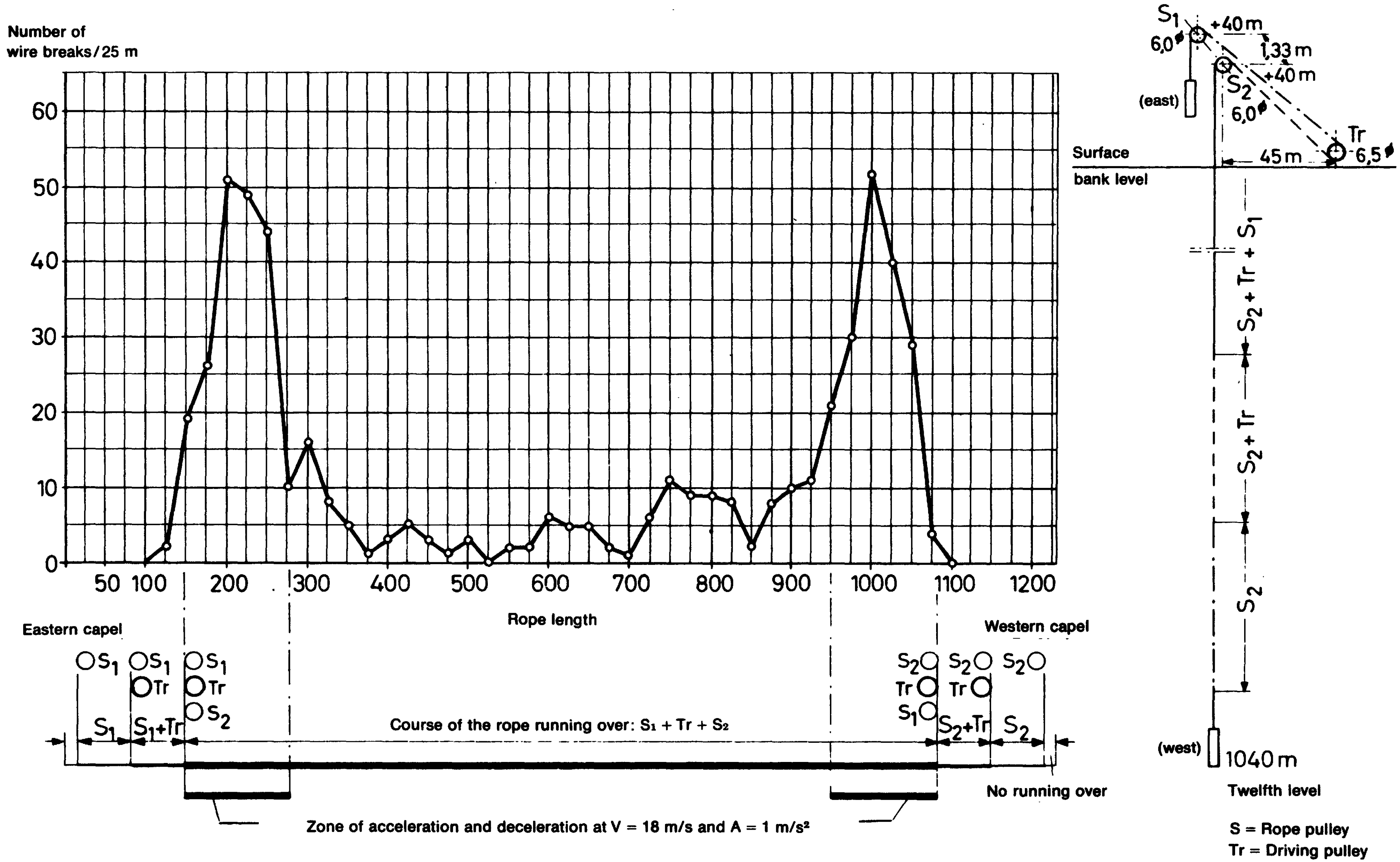
$\sigma_{obR\,dyn}$ = Maximum value of the heaving/bending stress in the vicinity of the deflector pulley

$\sigma_{obT\,K\,dyn}$ = Maximum value of the heaving/bending stress in the region of the driving pulley with transmission of forces

sta = Quasi static

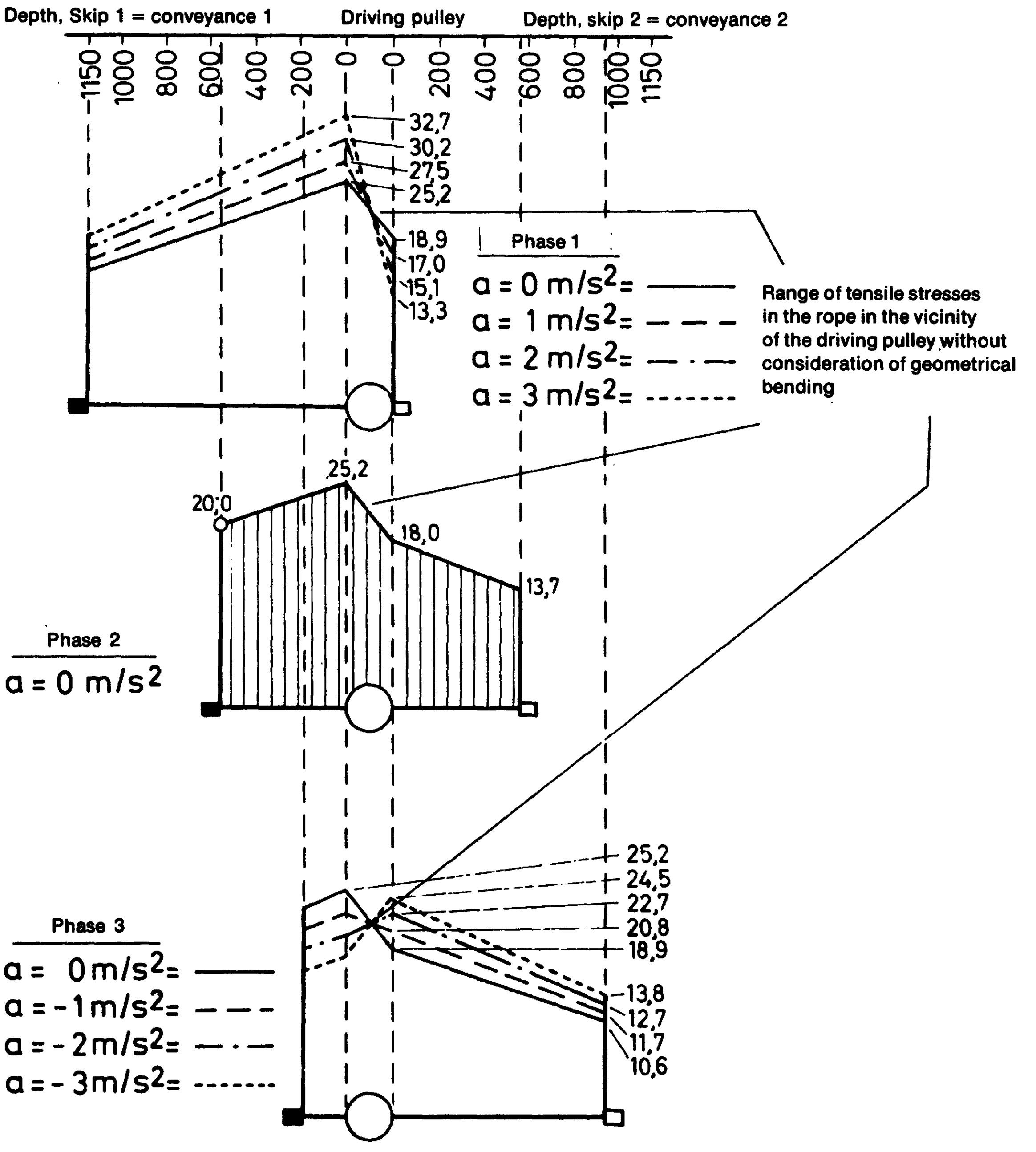
Concentration of wire breaks in a main-shaft rope in the zones of acceleration and deceleration

Fig. 4



Average tensile stresses in a rope in a four-rope towermounted winder allowing for starting-up accelerator and breaking deceleration

Fig. 5

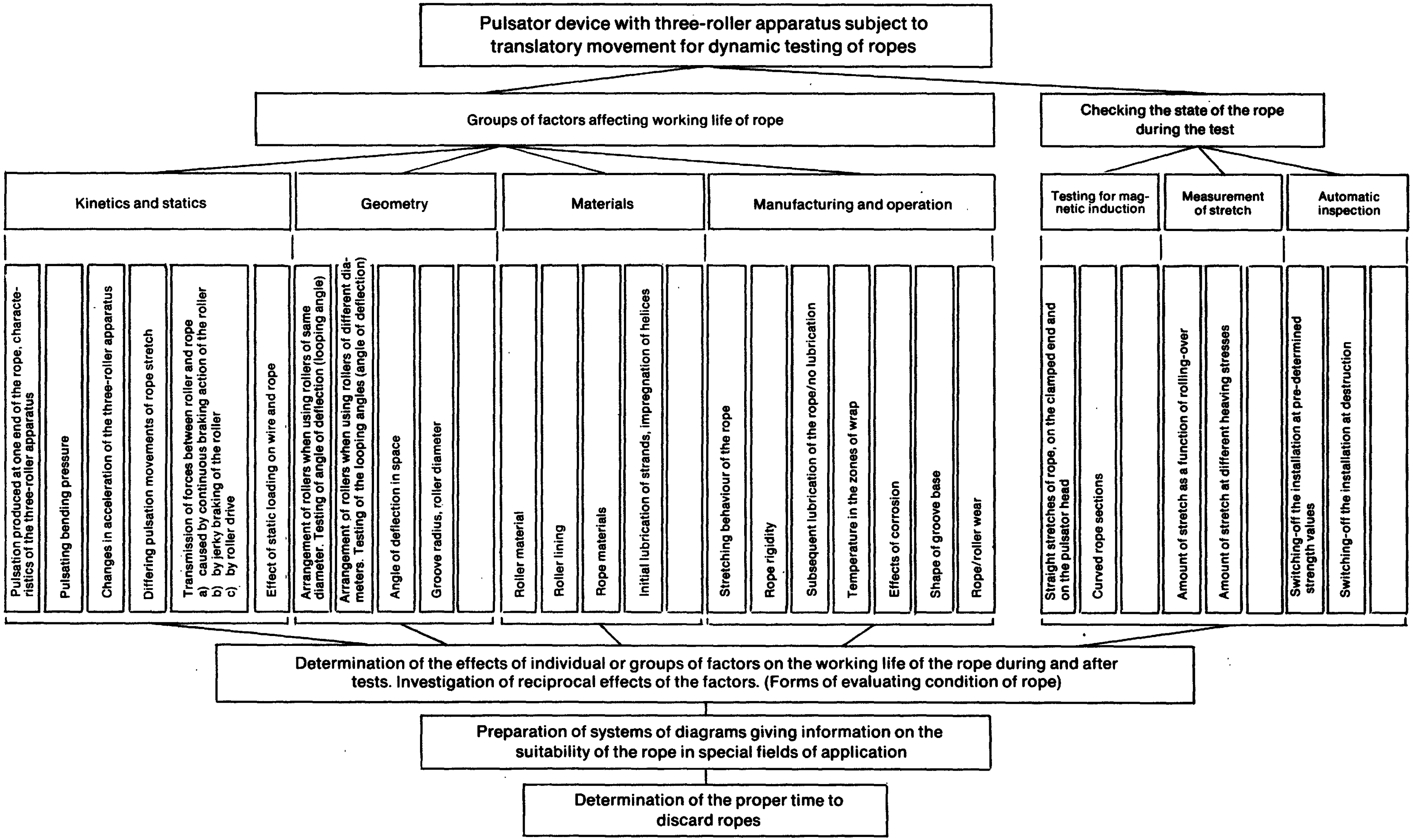


Large three-roller testing apparatus with magneto-inductive inspection of the state of the rope for dynamic rope tests

Fig. 6

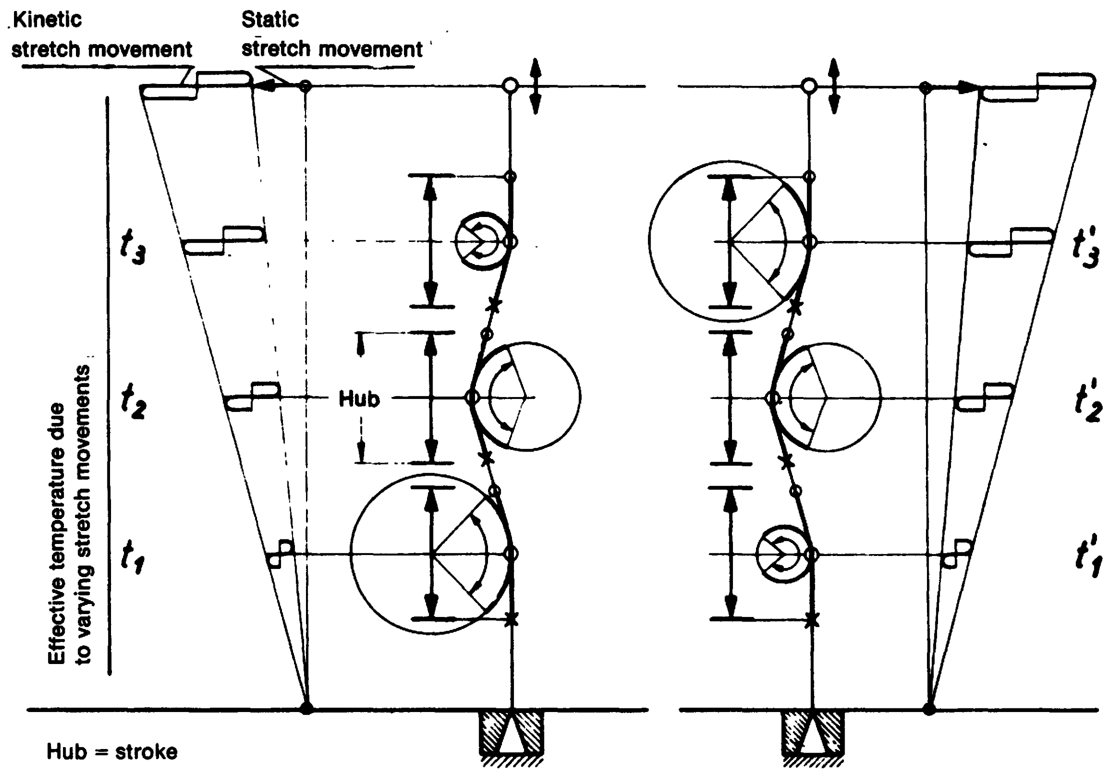
Fig. 7

Combined rapid dynamic testing method for ropes



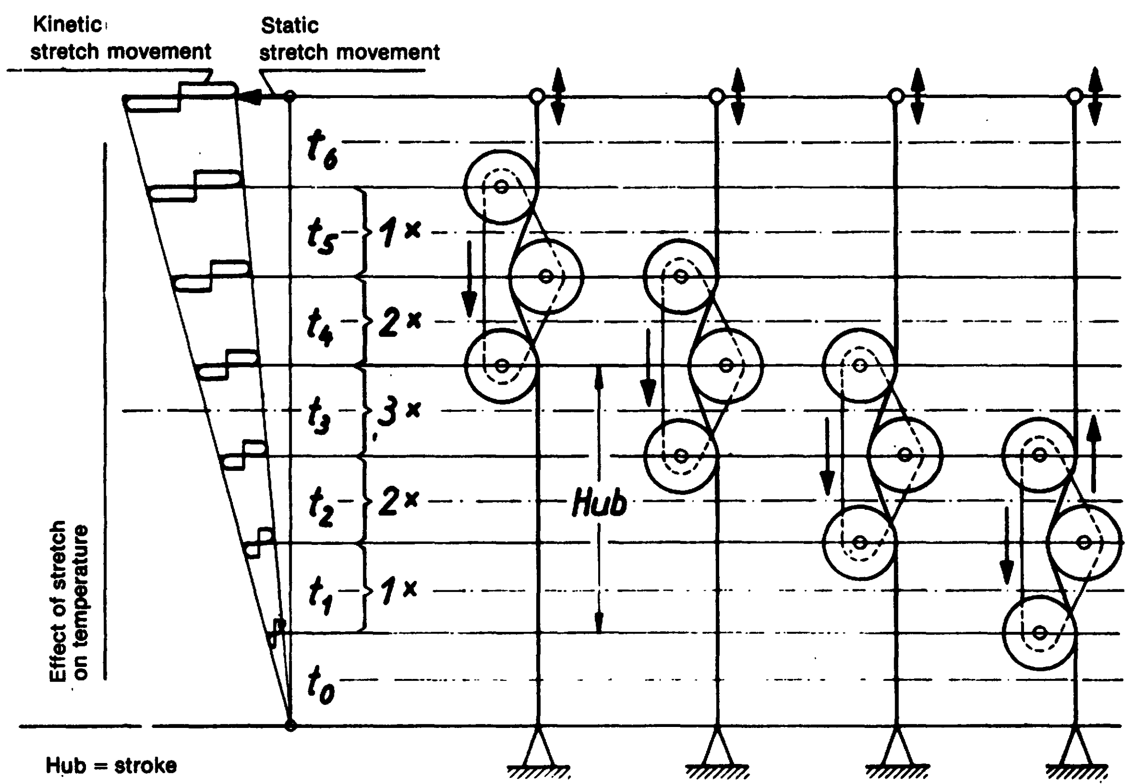
Three-roller apparatus with different roller diameters and rope sections rolled once round for one stroke

Fig. 8



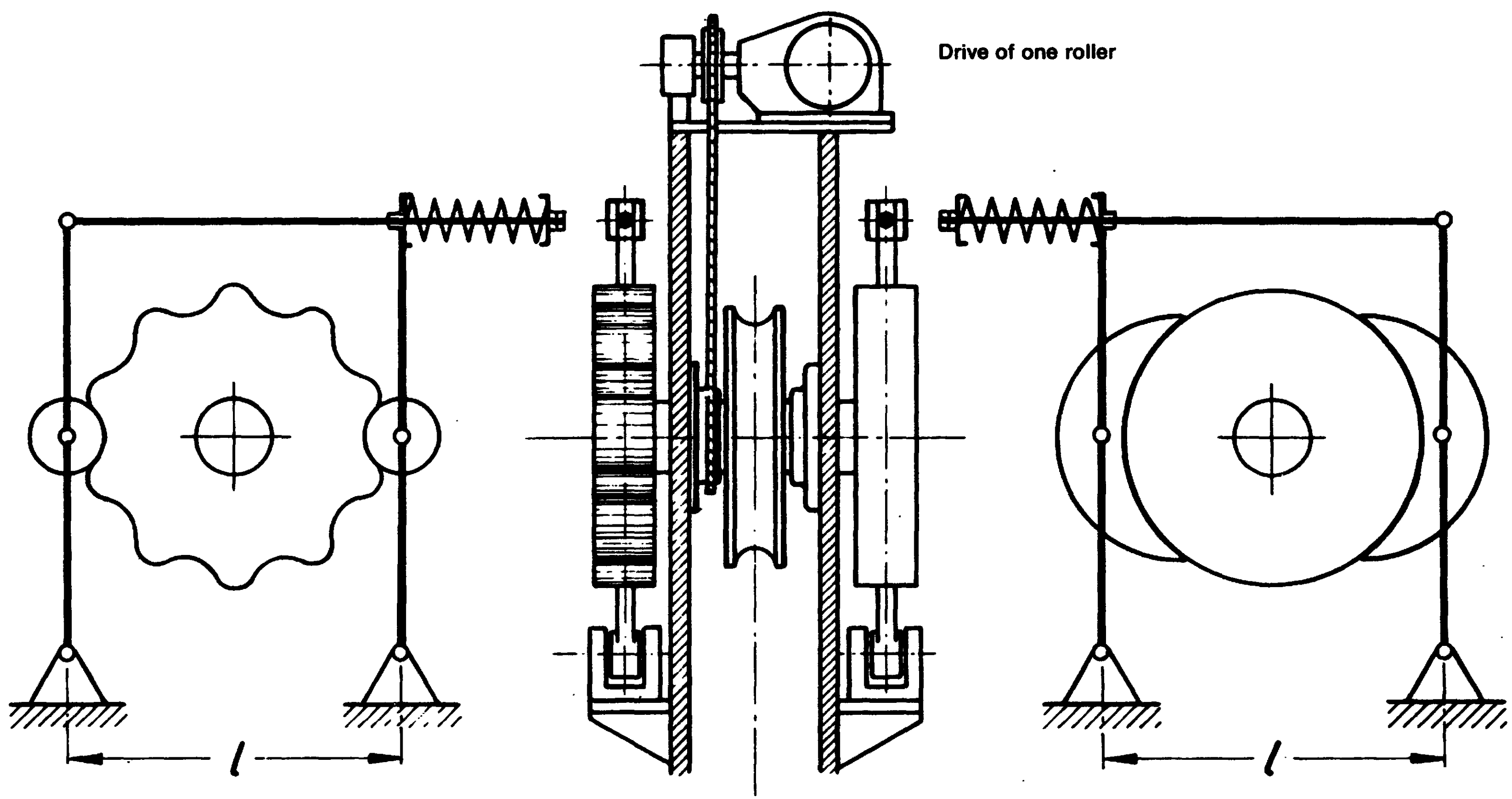
Three-roller apparatus with similar rollers Rope sections rolled 1 to 3 times for one stroke

Fig. 9



Continúous and shock-type braking and drive of one roller (partical view of a three-roller apparatus)

Fig. 10



Side view of the pulsation-producing device

Section of a three-roller apparatus

Side view of the brake arrangement

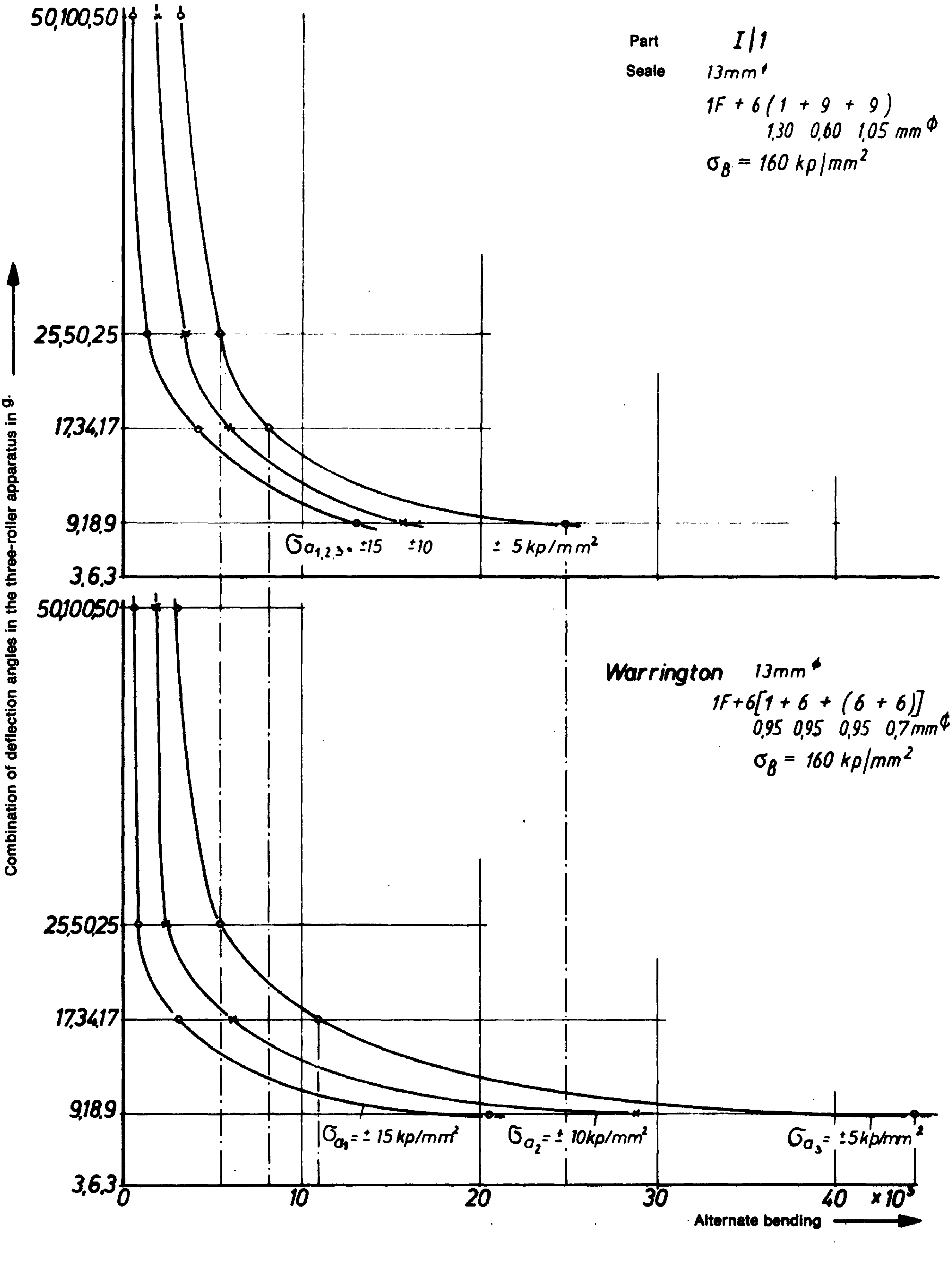
Diagram system for the assessment and selection of ropes which are subject to heaving/bending stresses

Fig. 11

Group classification / Type of presentation	Group I.	Group II.
Abscissa	Alternate bending	Alternate bending
Ordinate	Combination of deflection angles	Rope stress
Parameter	Rope stress	Combination of deflection angles
1. Comparison of the rope designs and manufactures under *different* loadings	Part groups I/1 I/1/M ù designs I/1/F ù manufactures	Part groups of II/1 II/1/M ù designs II/1/F ù manufactures
Parameter	Rope designs manufacture	Rope designs/manufacture
2. Comparison of different rope designs and manufactures under *similar* loading	Part groups of I/2 I/2/M/mK = Schm-Z I/2/F/oK = Schm-Z Schm-Z = lubrification state m.K. = with transmission of forces o.K. = without transmission of forces	Part groups of II/2 II/2/M/α/Schm-Z II/2/F/α/Schm-Z α = Combination of deflection angles

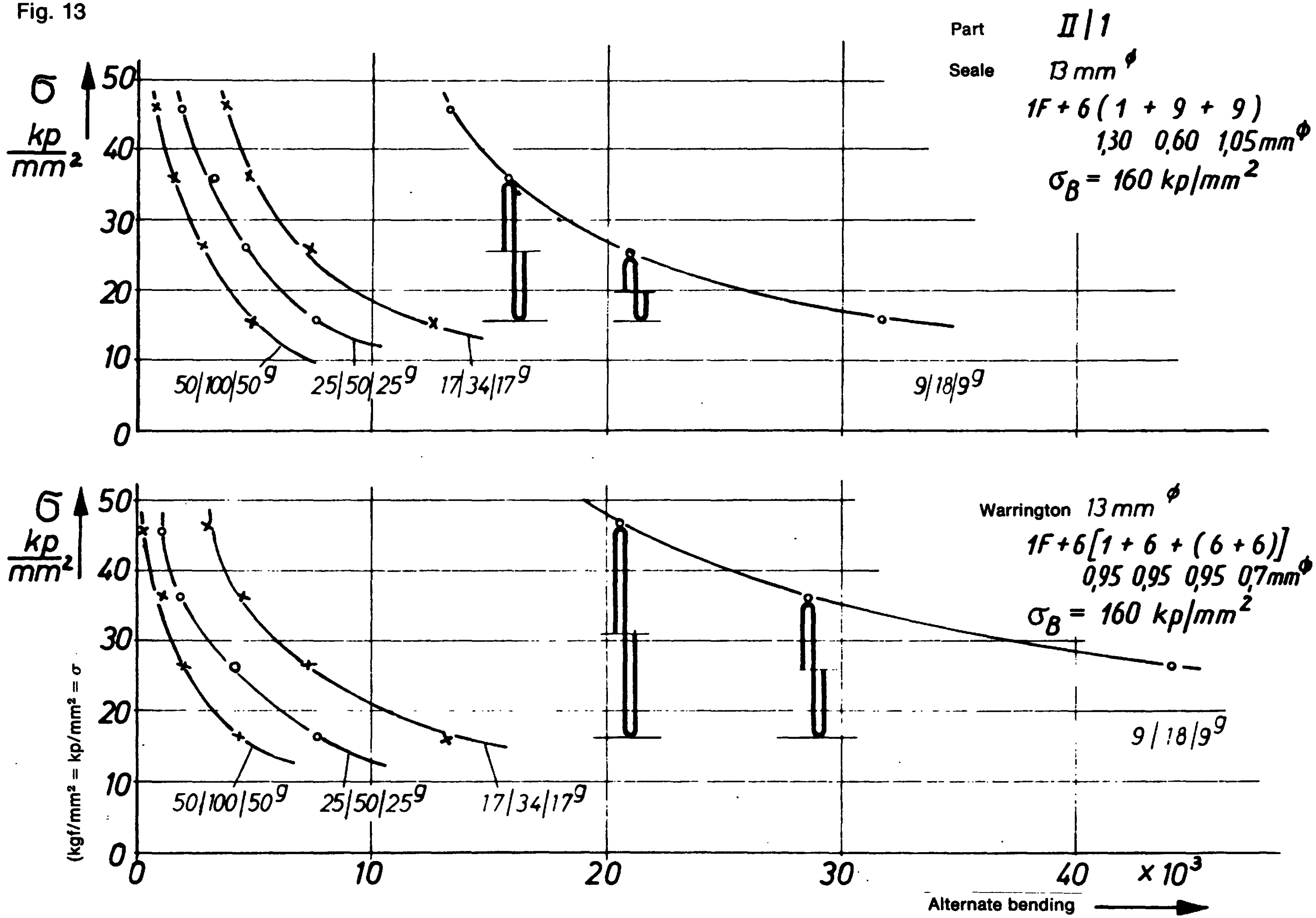
Assessment of the suitability of two-rope designs under varying geometrical and dynamic loadings
Parameter = range

Fig. 12



Assessment of two-rope designs under varying geometrical and dynamic loadings
Parameter = combination of deflector angles

Fig. 13



Assessment of the suitability of the various rope designs under varying combinations of deflection angle and range from + and − 5 and + and − 15 kp/mm²

Fig. 14

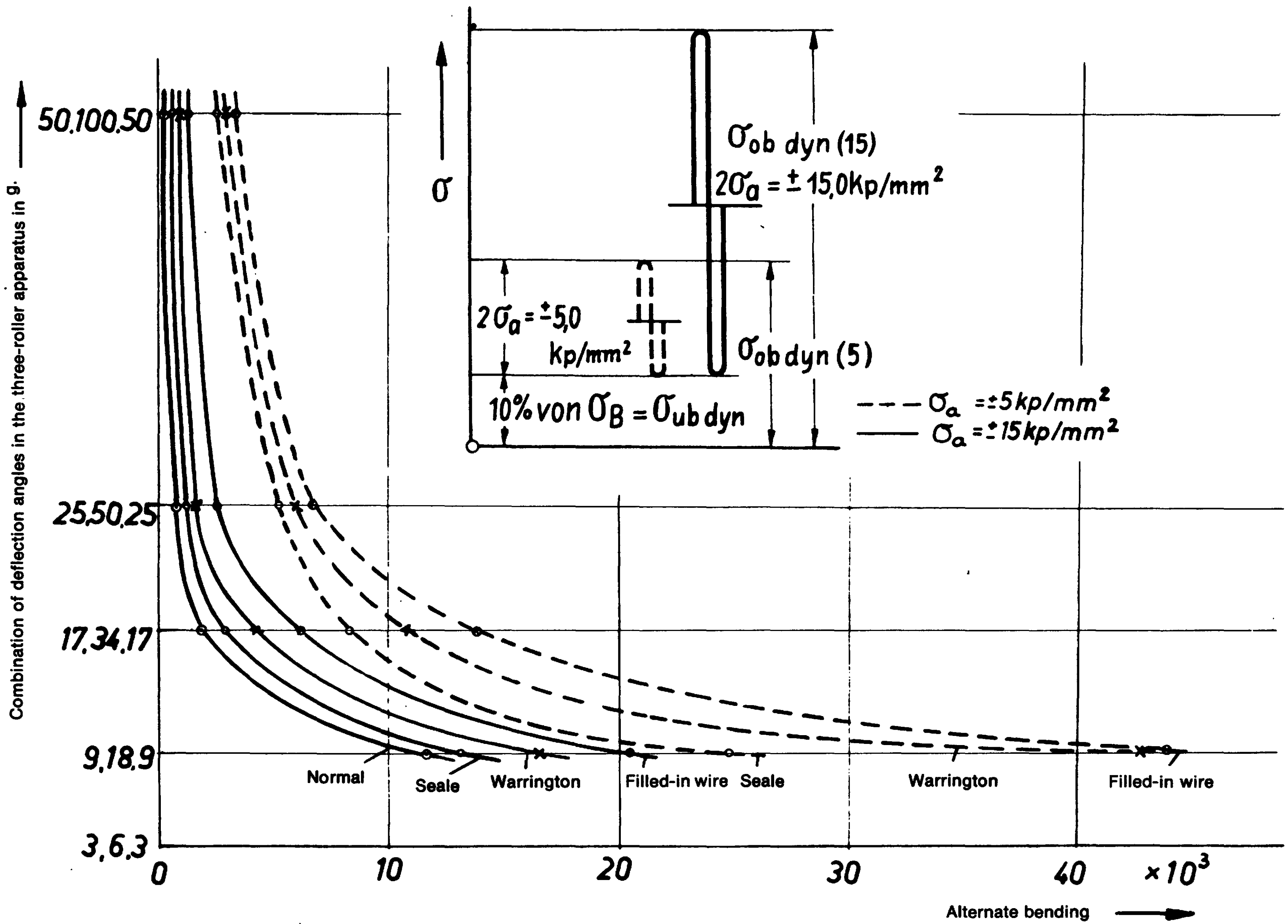


Fig. 15

Assessment of various rope designs under varying heaving/bending stresses and combinations of deflection angles

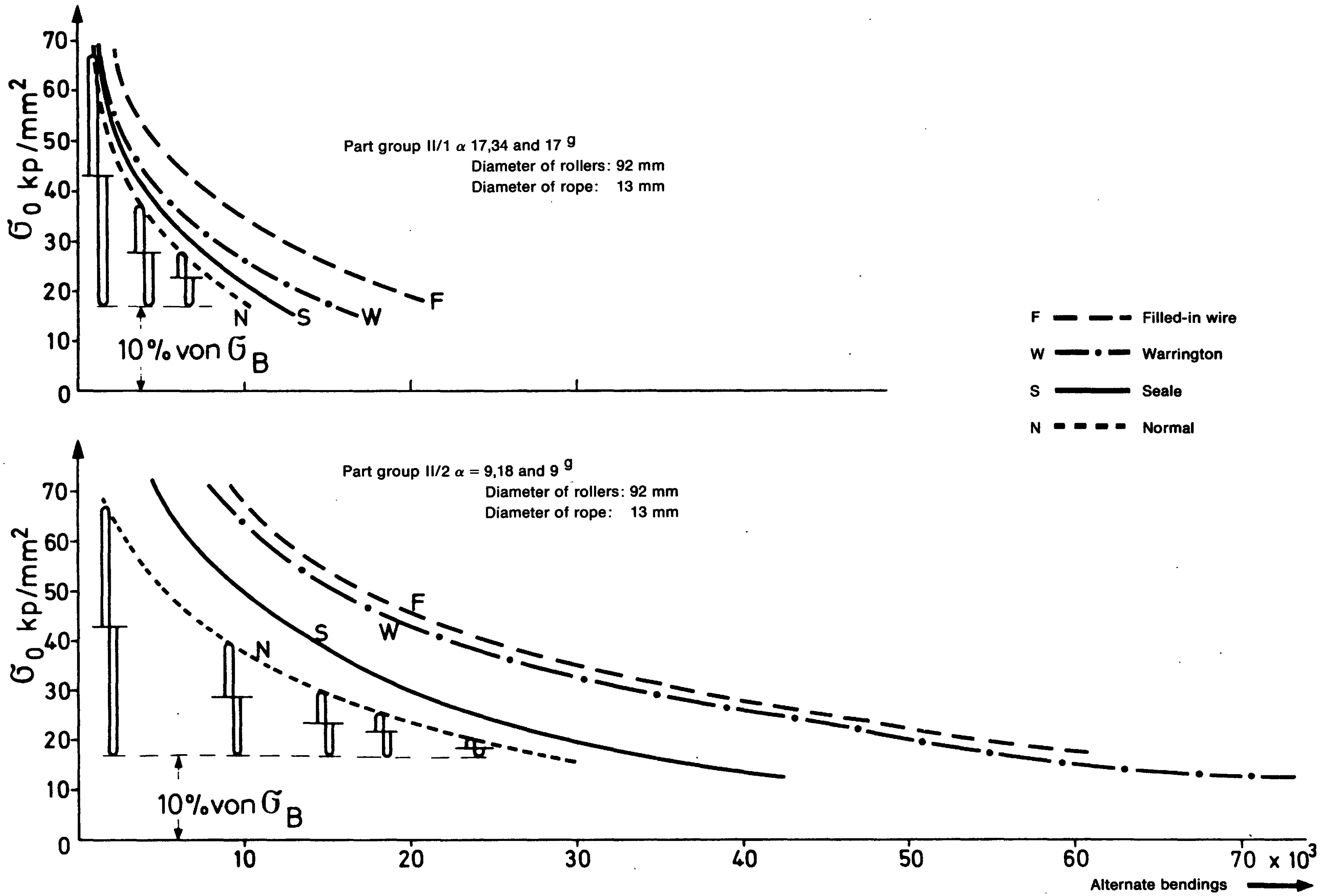


Fig. 16

Ropework formula for main- and staple-shaft ropes allowing for technological and dynamical loading

$$W_{dyn_{H(B)}} = \frac{z \cdot Zm}{1000 \cdot q_s} \cdot K_{H(B)} \begin{matrix} [\text{tkm/kg rope}] & \text{old} \\ [\text{Mpkm/kg rope}] & \text{new} \end{matrix}$$

Loading factor in main and staple shafts.

$$K_{H(B)} = 1 + \left[\left(\frac{S_1}{S_2} \cdot a - 1{,}30 \right) + \left(\frac{D/d_{mH(B)}}{D/d_m} \cdot s - 1 \right) + \left(\frac{p_m}{p_{m_{H(B)}}} \cdot b - 1 \right) \right]$$

z = Number of winds

Z_m = The average rope tension in the loaded drum

q_s = Weight of the rope in kp/m

D/d_{m_H} = 100, average ratio of driving pulley diameter to rope diameter in mainshaft

D/d_{m_B} = 60, average ratio of driving pulley to rope diameter in staple shaft

a = Acceleration factor, type and magnitude of acceleration or deceleration allowed for

S_1/S_2 = Ratio of rope forces, fully-loaded rope to unloaded rope

s = Factor allowing for the number of rope pulleys and the diameter of the rope pulleys

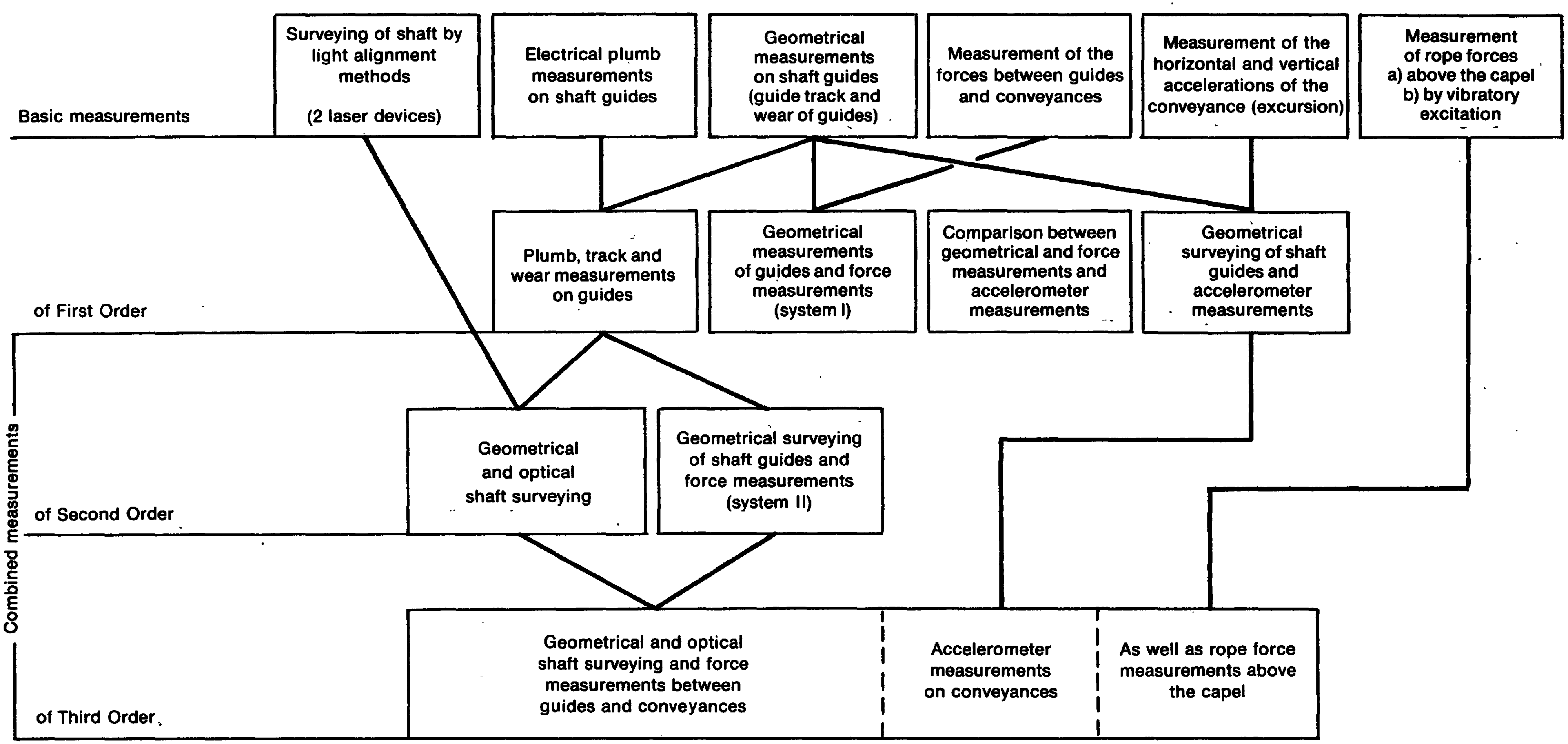
b = Bedding factor for driving and rope pulleys

p_{m_H} = 15 kp/cm², average surface pressure in main shaft winders of rope and driving pulleys/rope and rope pulley

p_{m_B} = 25 kp/cm², average surface pressure in staple shafts of rope and driving pulleys/rope and rope pulley

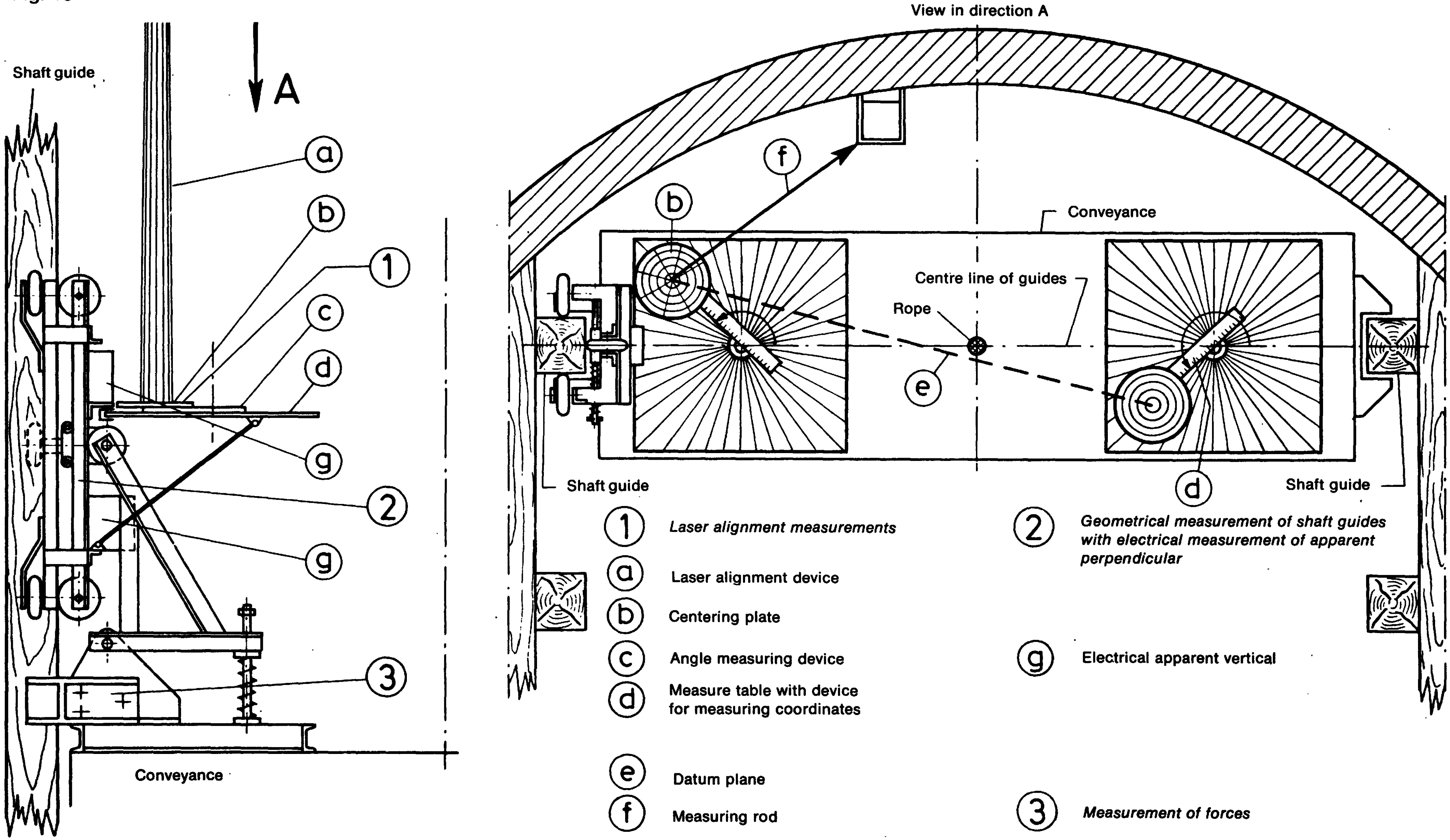
Measurements on shaft guides and winding ropes

Fig. 17



Methods for making measurements on shaft guides and in shafts

Fig. 18



(1) *Laser alignment measurements*

(a) Laser alignment device

(b) Centering plate

(c) Angle measuring device

(d) Measure table with device for measuring coordinates

(e) Datum plane

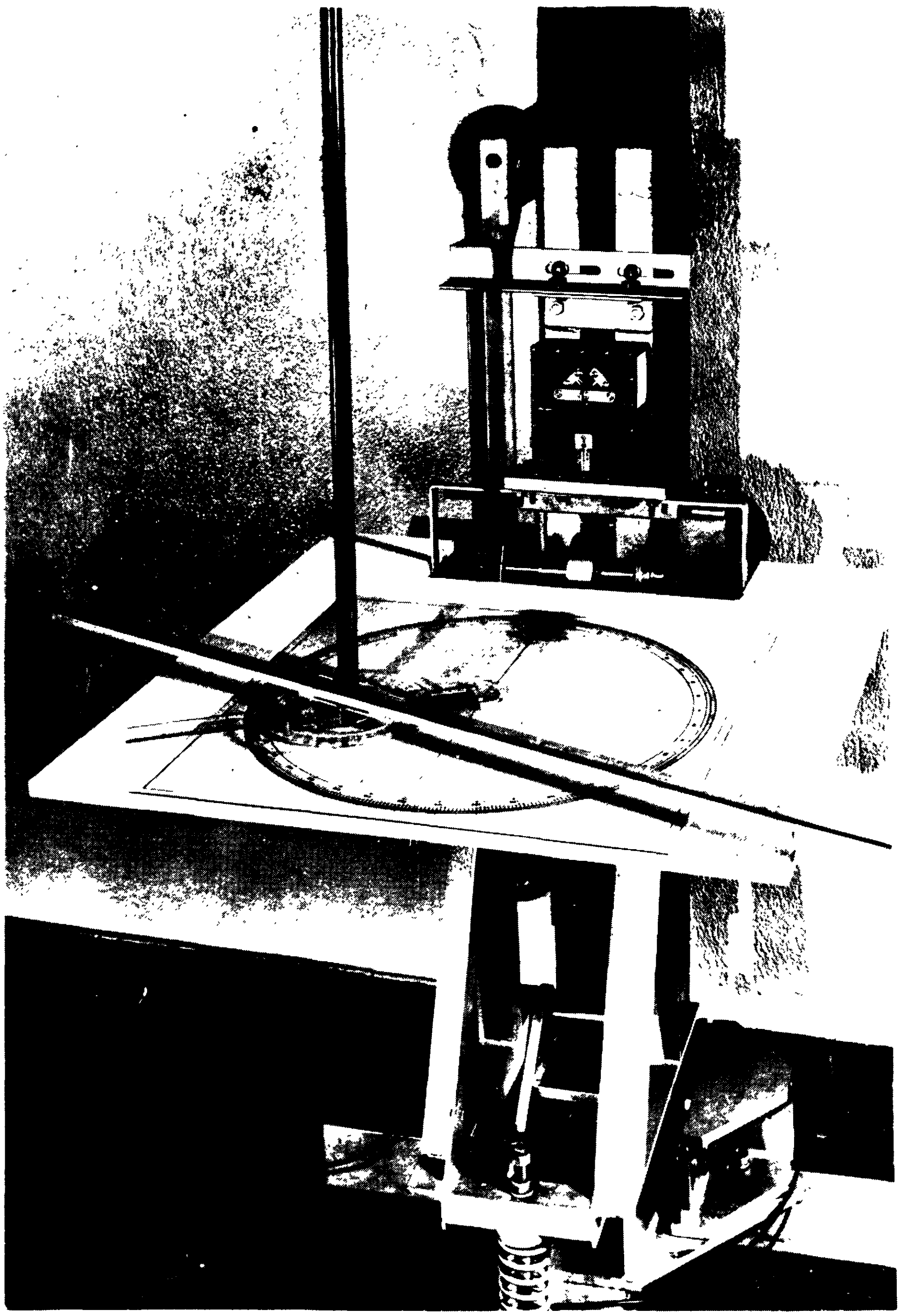
(f) Measuring rod

(2) *Geometrical measurement of shaft guides with electrical measurement of apparent perpendicular*

(g) Electrical apparent vertical

(3) *Measurement of forces*

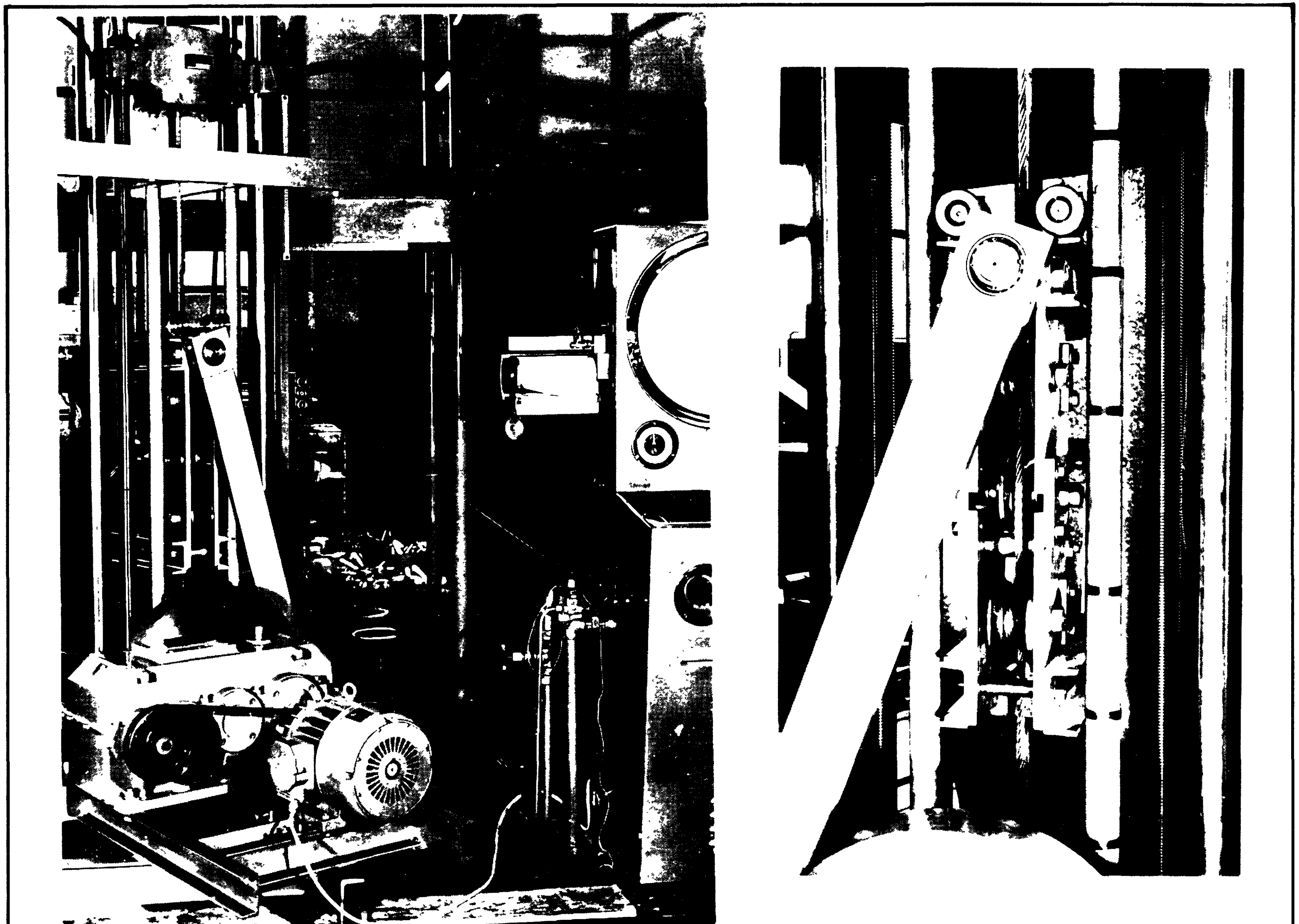
Fig. 19



One half of the combined shaft-guide measuring device with geometrical measurements of guides, force measurements between guides and conveyance, and surveying of shaft and guides with laser alignment device

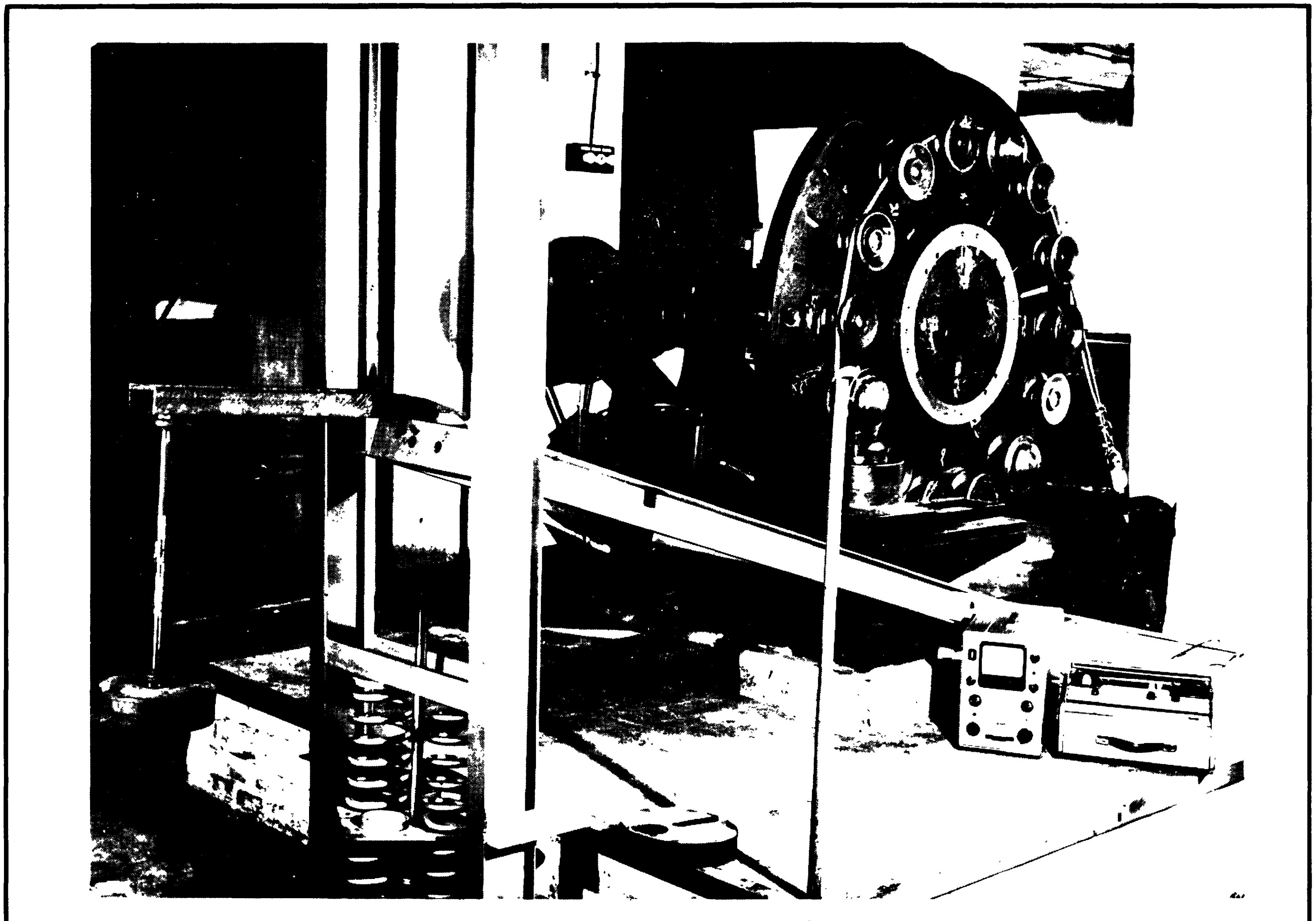
Fig. 20

Three-roller apparatus subjected to translatory movement, for dynamic tests of roadway-haulage ropes



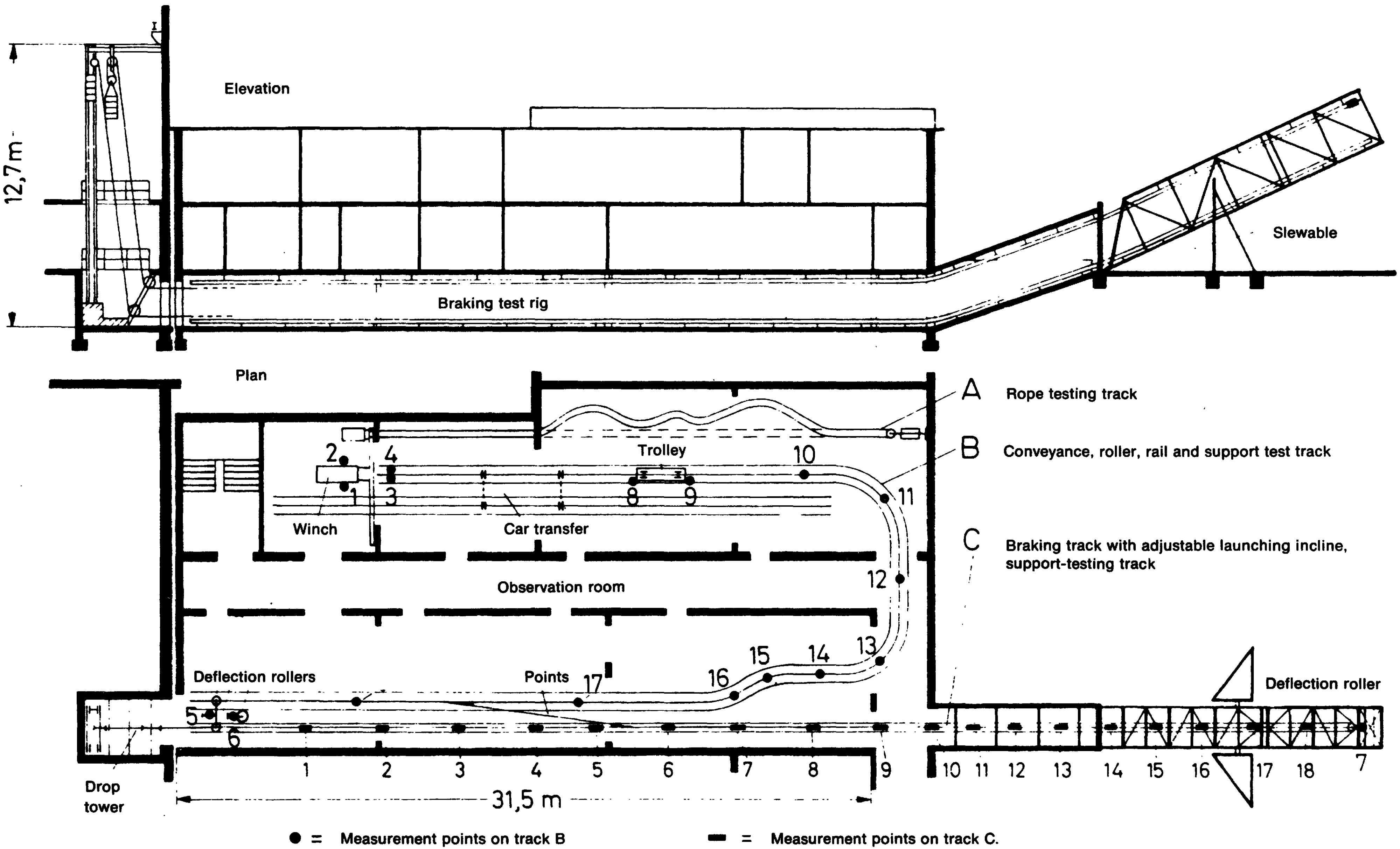
Rotating rope and roller test-brake for roadway/haulage ropes

Fig. 21



Testing area for rope-driven roadway conveyances in the basement of the Seilprüfstelle

Fig. 22



Electrical heaving-stress measurement device for rope-driven roadway-haulage installations

Fig. 23

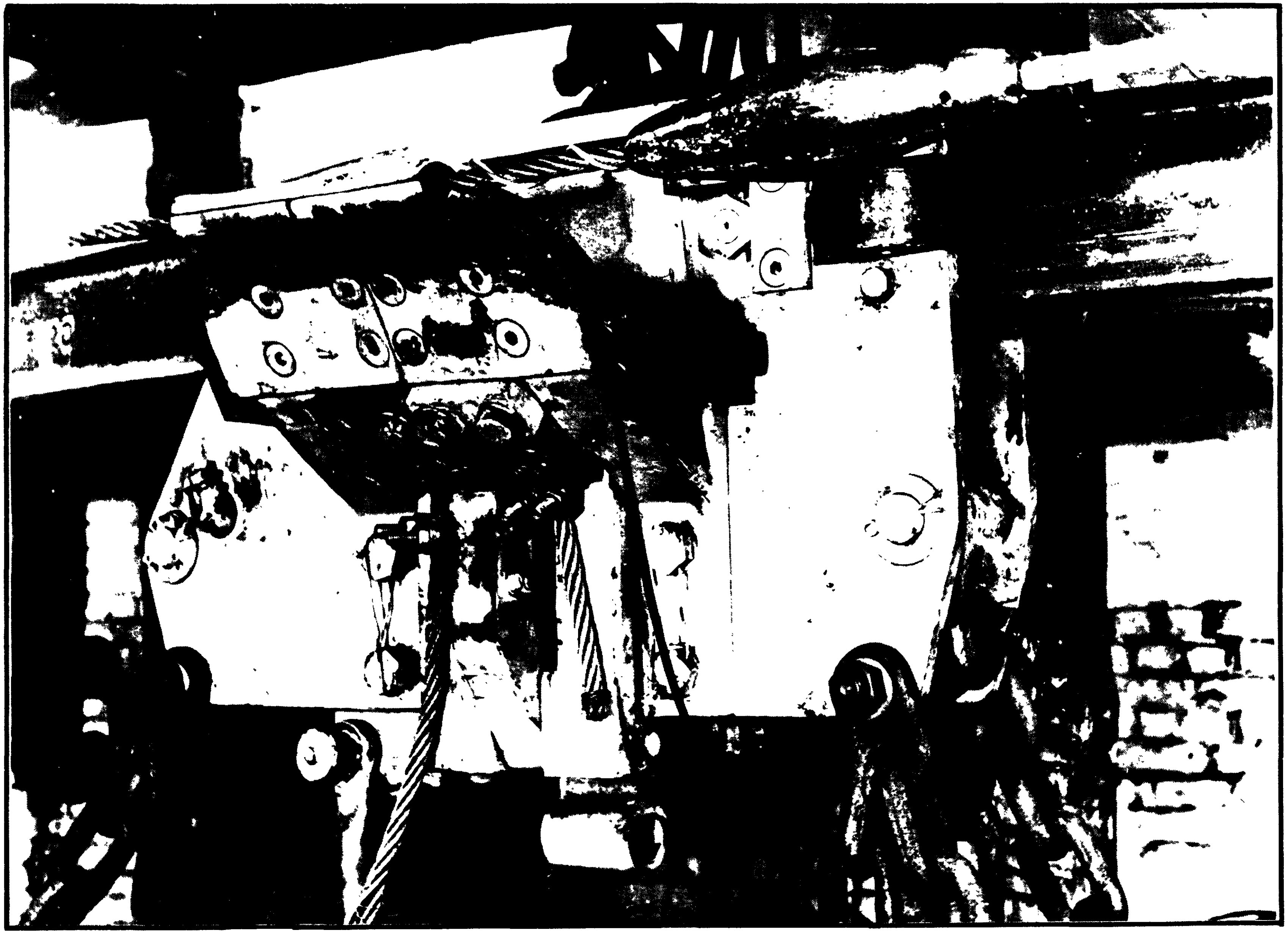


Fig. 24

Stress measurement and classification device for ropes used in roadway/haulage installations

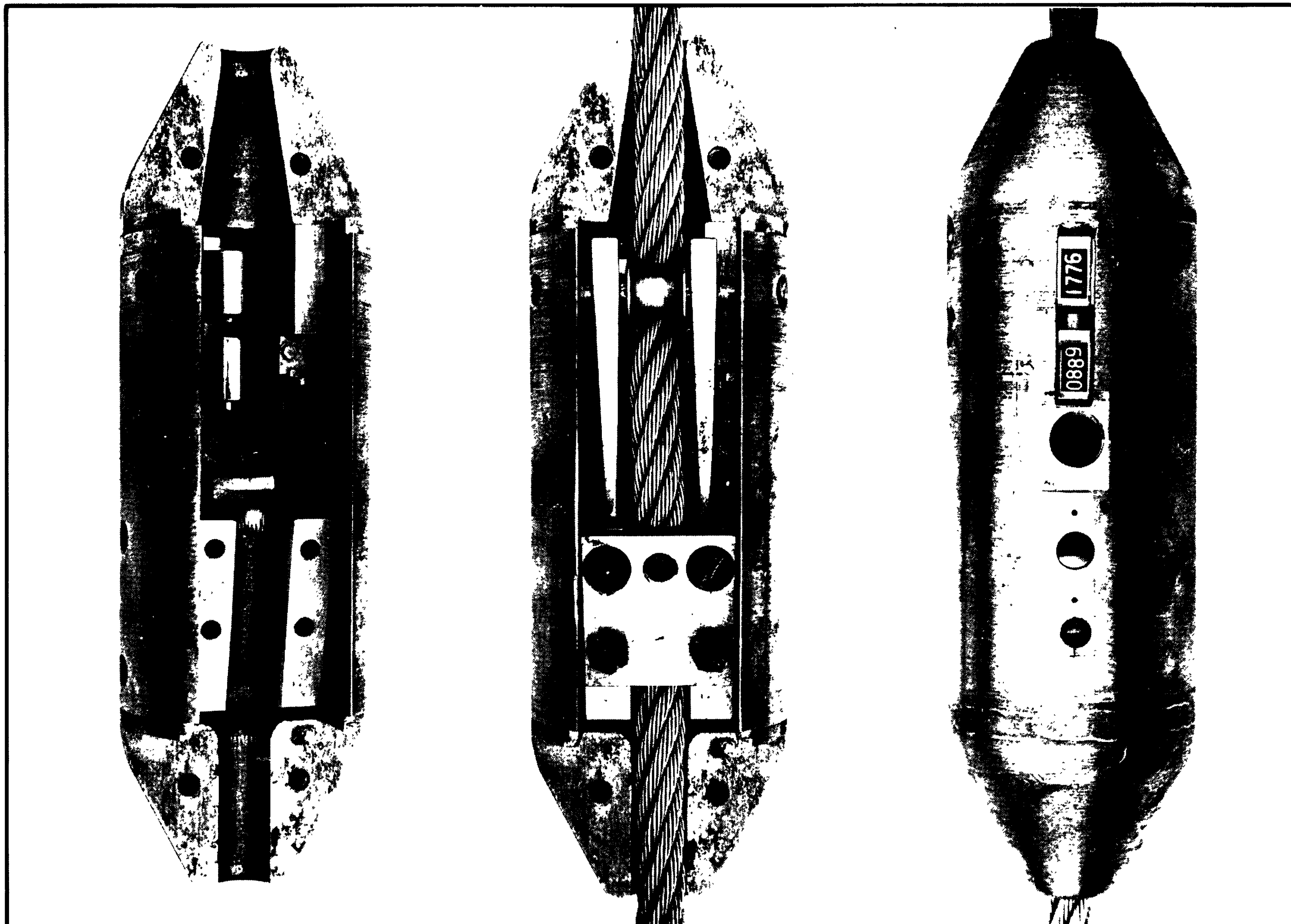


Table to determine the geometrical and kinetic loading indices a_g and a_k of ropes used for roadway haulage

Fig. 25

Geometrical co-efficient — Non permitted values (hatched)

Angle of deflection [g] / D/d ratio: return roller / deflection roller	D_u/d 30	D_u/d 30-40	$> D_u/d$ 40
	$D_A/d < 7$	D_A/d 7 - 9	$D_A/d > 9$
Only for return rollers 100 - 200 ^{g}	2,5	2,0	1,5
Only for deflection rollers 0 - 10 ^{g}	1,1	1,0	0,9
10 - 20 ^{g}	2,3	2,1	1,95
20 - 30 ^{g}	3,7	3,3	3,05
30 - 40 ^{g}	5,3	4,6	4,2
40 - 50 ^{g}	7,1	6,0	5,4
50 - 60 ^{g}	9,1	7,5	6,65

Kinetic co-efficient

In excess of basic stress	Loading co-efficient
$\sigma_{Gr} = 15\,\%\,\sigma_B$	1,0
$< 40\,\% = 21\,\%\,\sigma_B$	1,3
$40\text{-}80\,\% = 27\,\%\,\sigma_B$	2,3
> 80 %	3,3

Multiplication factors for the geometrical co-efficients

Condition of the groove		Deflection from plane	
Good	0,95	$< 5^g$	1,0
Adequate	1,00	$5 - 10^g$	1,10
Unsatisfactory	1,10	$> 10^g$	1,20

Fig. 26

Example of the determination of the kinetic and geometrical loading indices ak and ag

Kinetic loading index:

$$a_k = \frac{\sum_{1}^{3} \text{Number of changes of force in a region} \times \text{Corresponding kinetic co-efficient}}{\text{rolled-over length of rope in metres}}$$

[2,3] ← new co-efficient

$$= \frac{47 \cdot 1{,}3 + 14 \cdot 2{,}3 + 5 \cdot 3{,}3}{520} = 0{,}21 \quad [0{,}20]$$

corrected loading index

↑ co-efficient lies above the permissible limit

Geometrical loading index:

co-efficient for rolling round

co-efficients for deflection

multiplication factor for deflection from the plane

$$a_g = \frac{3 \cdot 2{,}5 + 12 \cdot 2{,}1 + 9 \cdot 3{,}3 + 2 \cdot 4{,}2 \cdot 1{,}1}{\text{rolled-over length of rope} = 520\ \text{m}} = 0{,}29$$

Fig. 27

The rope work formula for rope-driven roadway-haulages

$$W_{Str} = \underbrace{\frac{z \cdot Z_{m\,Str}}{1000 \cdot q_s}}_{\text{Work term W}} \cdot \underbrace{\left[1 + \left(\frac{6}{S} \cdot \alpha_k - 1\right) + \left(\frac{[D_T/d]_m}{D_T/d} \cdot \alpha_g - 1\right)\right]}_{\text{Classification magnitude } Str} \text{ in Mpkm/kp}$$

Work term W

W

Classification magnitude $_{Str}$

z = Total number of winds (outward and return)

Z_{mStr} = Average value of rope winds in the fully-loaded and unloaded strands

q_s = Weight per metre of the rope

6 = Prescribed rope safety index for roadway conveyances when hauling materials

S = Existing rope safety index

α_k = Kinetic rope loading factor

α_g = Geometrical rope loading factor

D_T = Diameter of driving pulley

d = Rope diameter

$[D_T/d]_m$ = Average value of the ratio DT/d in roadway rope haulages in the Ruhr

Fig. 28

Table to determine the degree of difficulty in the rope-driven roadway haulage from the degree of rope loading and the degree of danger in the event of rope break

Loading indices: Kinetic a_k; geometrical a_g ↓	Value calculated by the Seilprüfstelle der WBK					>
Loading factors α_k and α_g ↓	0,8	0,9	1,0	1,1	1,2	> 1,2
Classification magnitudes ≙ K_{Str}	< 0,7	0,7-0,9	0,9-1,1	1,1-1,3	1,3-1,5	> 1,5
Degree of rope loading ↓	I_K	II_K	III_K	IV_K	V_K	> V_K
Degree of difficulty of the installation. Example $\frac{II_K + V_D}{2} = 3{,}5$	1,0 · 1,5	2,0 · 2,5	3,0 · 3,5	4,0 · 4,5	5,0	> 5,0
Degree of danger in the event of rope break ↑	I_D	II_D	III_D	IV_D	V_D	> V_D
	up to 5^g	up to 10^g	up to 20^g R	up to 30^g R	up to 50^g R	> 50^g
R = Curve in space	Level, throughs up to 5^g, adequate recovery length	Level to stretches inclined to 10^g, adequate recovery distance	Stretches inclined up to 20^g, adequate recovery distance	Stretches inclined up to 30^g, recovery distance not adequate	Inclined up to 50^g, recovery distance not adequate	Non-permitted zone

Fig. 29

Standard sheet for rope atlas Nr. VI - B - 25 - 15

92 - 92 - 92

Rope design: filled-in rope 1 F + 6 [1 + 6 + 6 + 12; Wire-ϕ 0,9 0,9 0,4 0,85]

Type of lubrication

Type of impregnation

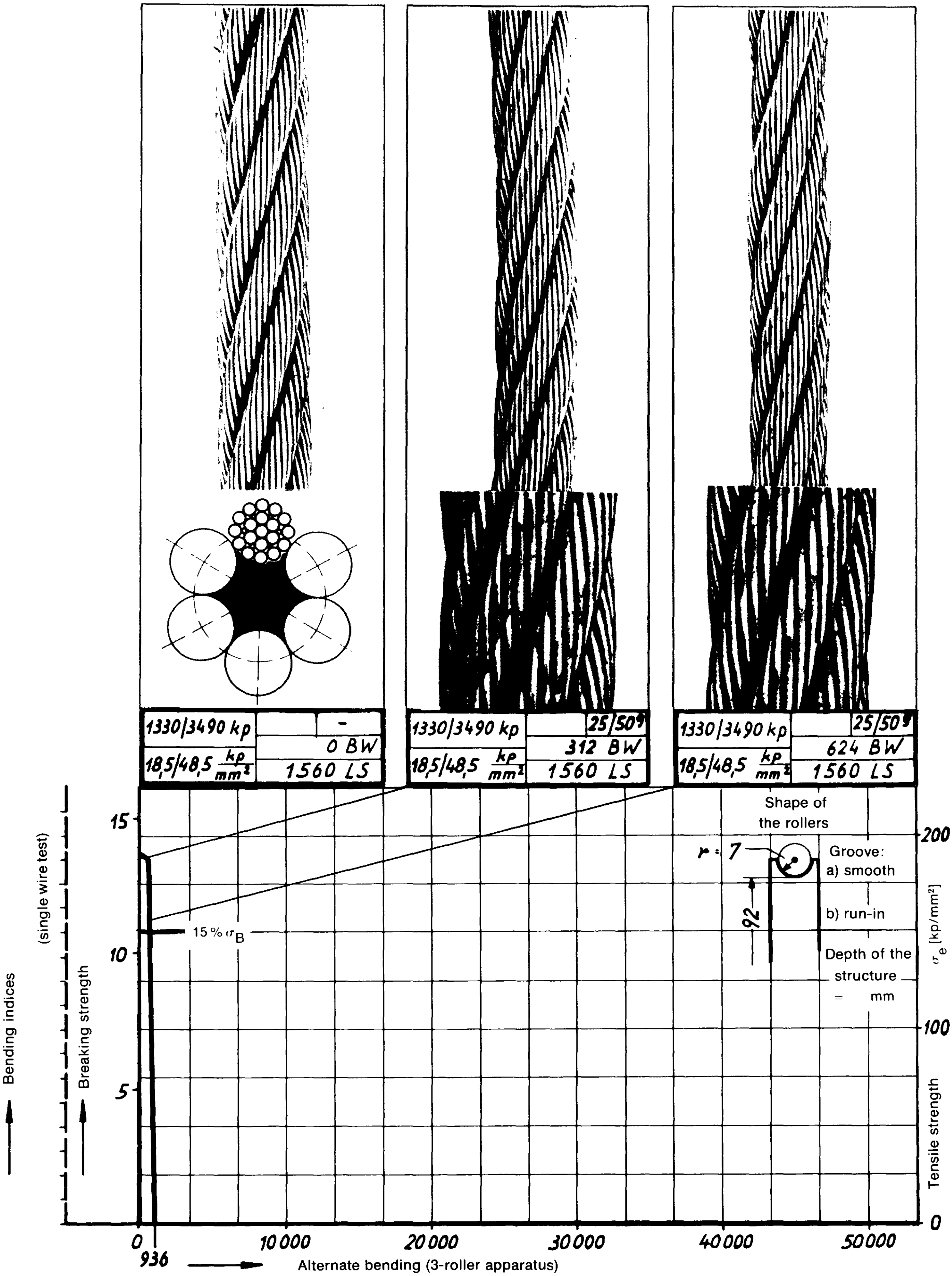


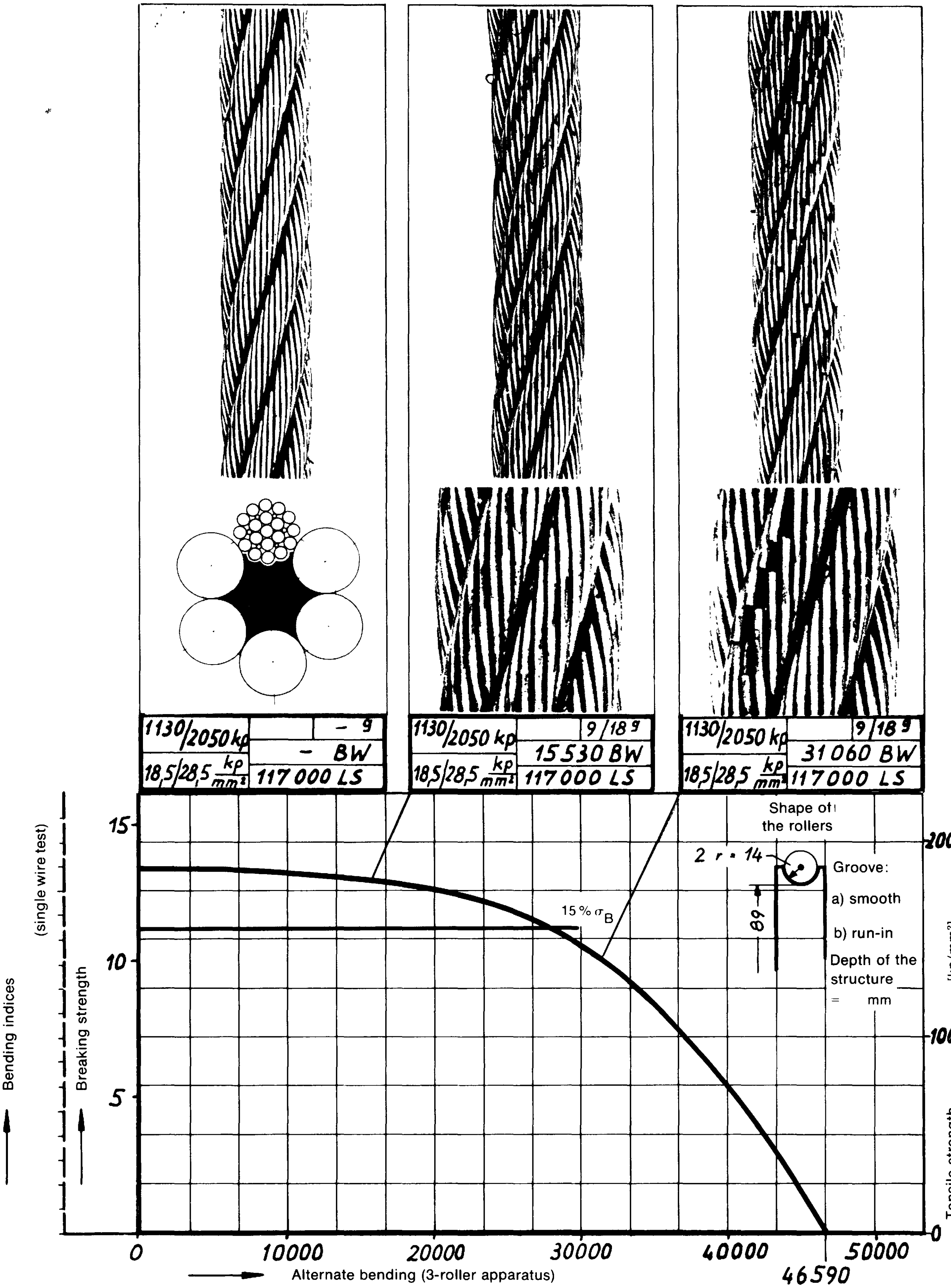
Fig. 30

Standard sheet for rope atlas Nr. VI - B - 9 - 5
89 - 89 - 89
13 ϕ

Rope design: filled-in rope 1 F + 6 [1 + 6 + 6 + 12 / Wire-ϕ 0,9 0,9 0,4 0,85]

Type of lubrication

Type of impregnation



Standard sheet for rope atlas Nr. III - B - 25 - 5

92 - 92 - 92

13 ϕ

Fig. 31

Rope design: Seale   1 F + 6 [1 + 9 + 9]   Wire-ϕ [1,3 0,6 1,05]

Type of lubrication

Type of impregnation

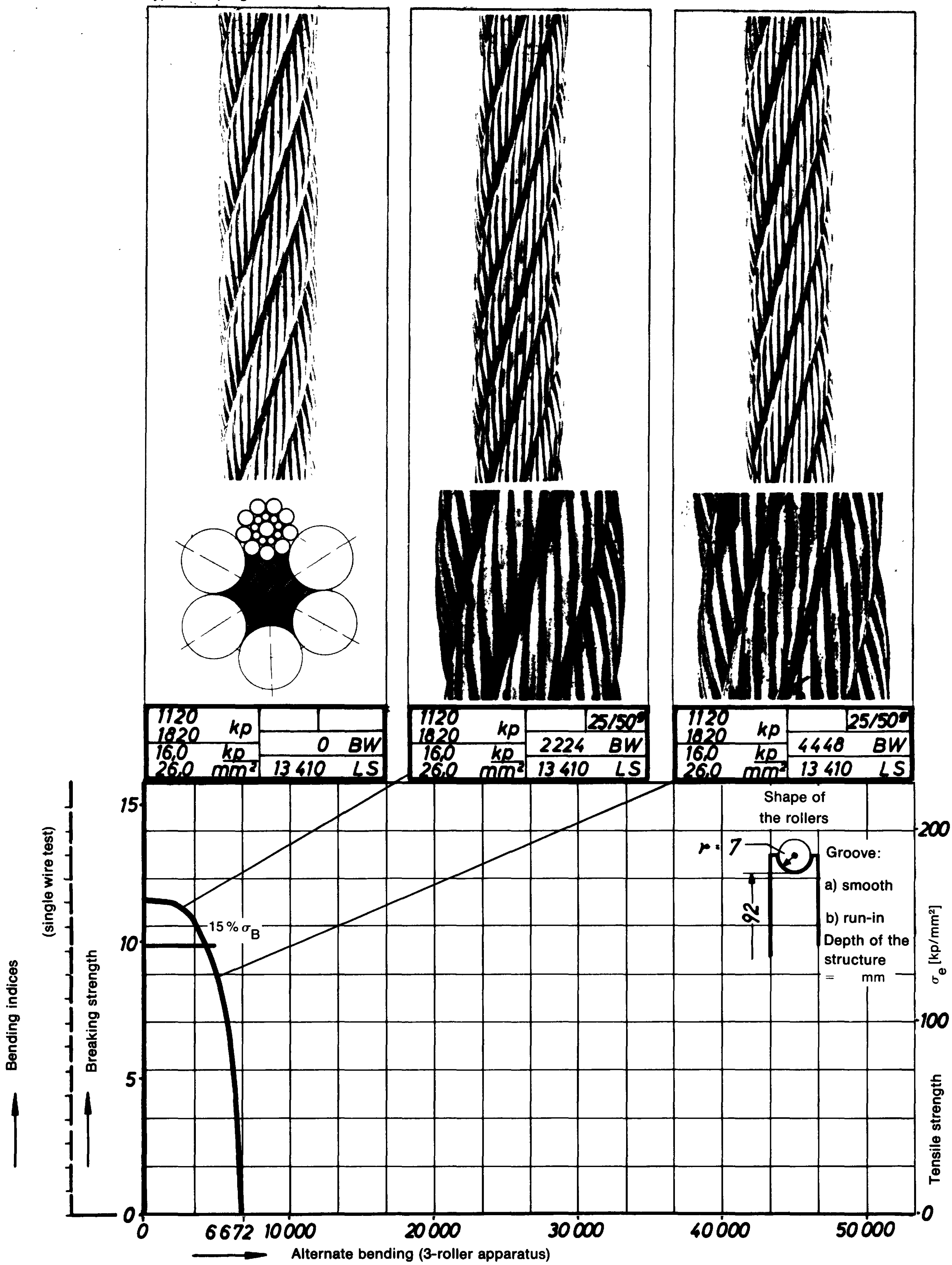


Fig. 32

Standard sheet for rope atlas Nr. III - B - 9 - 10
89 - 89 - 89

Rope design: Seale 1 F + 6 [1 + 9 + 9]
Wire -ϕ [1,3 0,6 1,05]

Type of lubrication Degreased

Type of impregnation

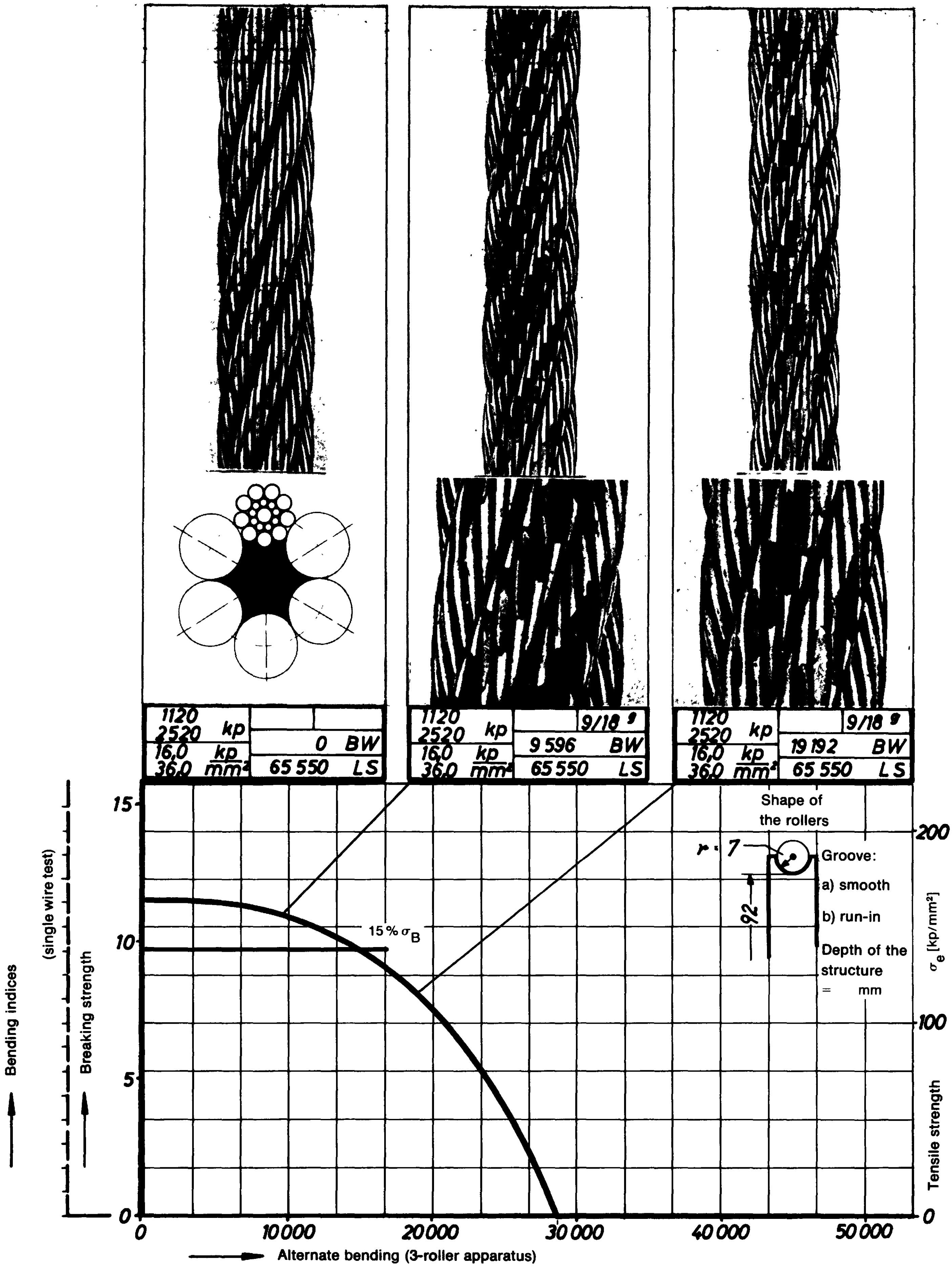


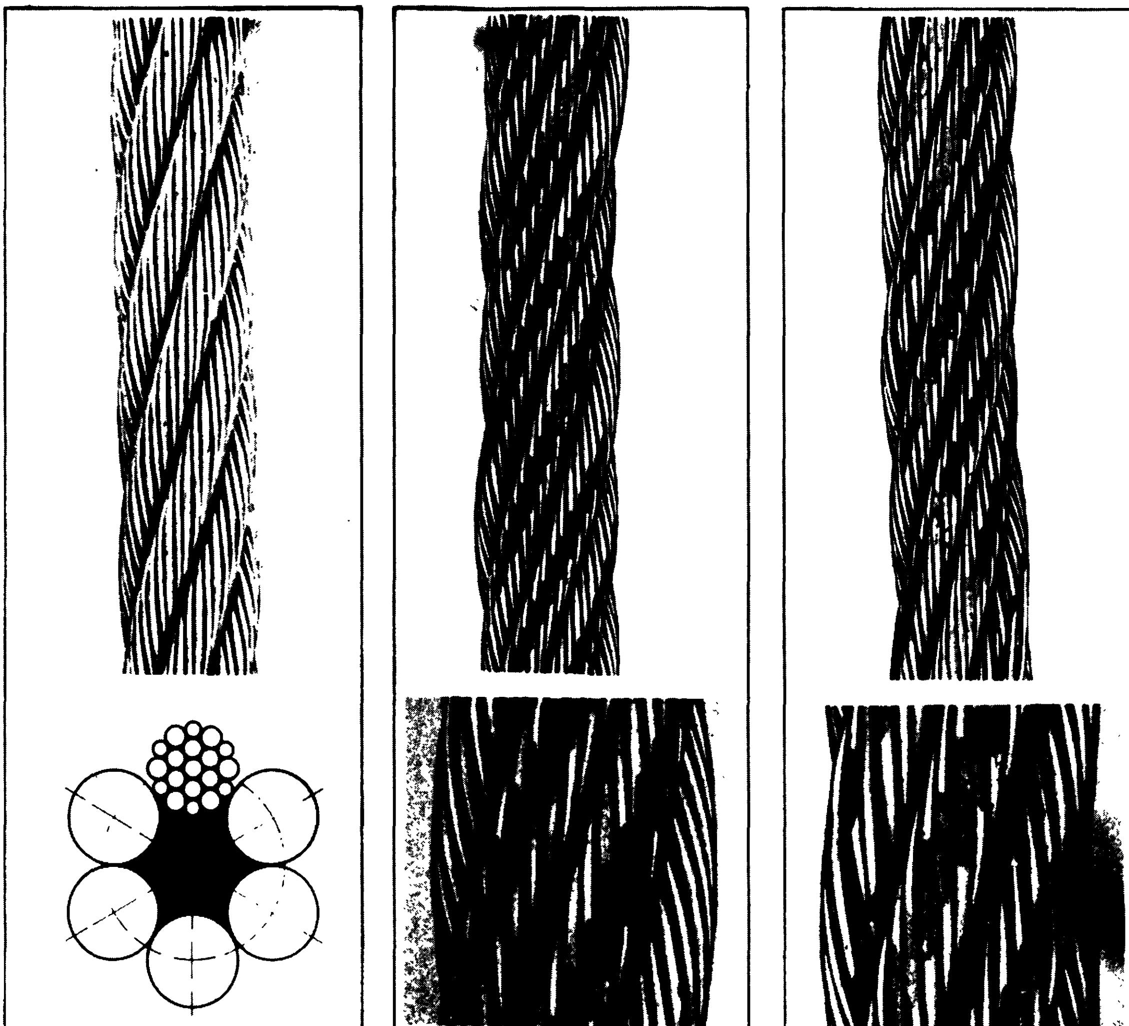
Fig. 33

Standard sheet for rope atlas Nr. IX - A - 25 - 15
92 - 92 - 92
13ϕ

Rope design: Warrington 1 F + 6 $\begin{bmatrix} 1+6+6+6 \\ 0{,}95\ 0{,}95\ 0{,}95\ 0{,}70 \end{bmatrix}$ Wire-ϕ

Type of lubrication

Type of impregnation



1200/3450 kp	
16,0/46,0 $\frac{kp}{mm^2}$	0 BW
	1590 LS

1200/3450 kp	25/50 g
16,0/46,0 $\frac{kp}{mm^2}$	230 BW
	1590 LS

1200/3450 kp	25/50 g
16,0/46,0 $\frac{kp}{mm^2}$	460 BW
	1590 LS

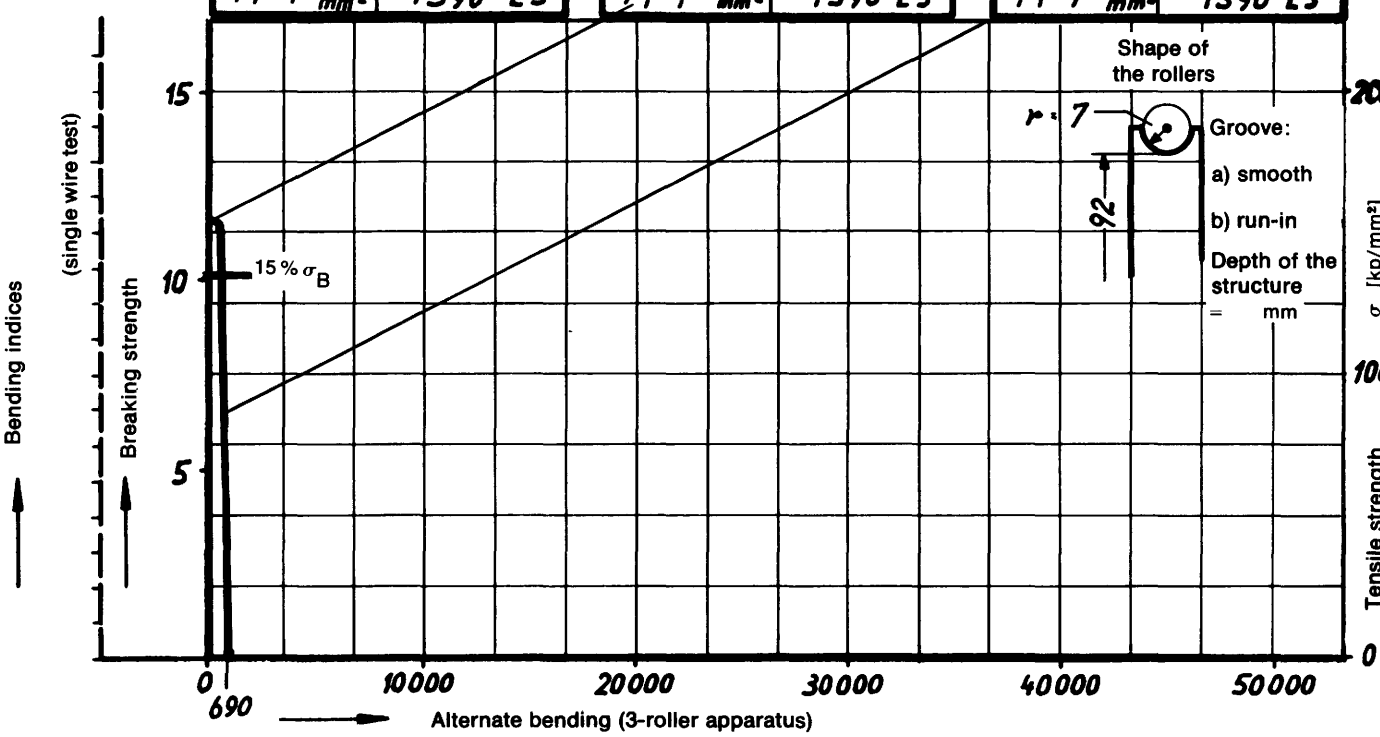


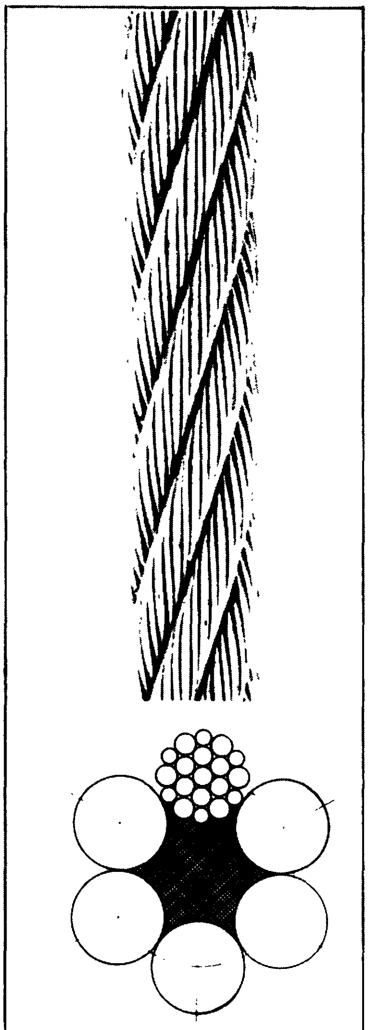
Fig. 34

Standard sheet for rope atlas Nr. IX - A - 9 - 5
92 - 92 - 92
13 ϕ

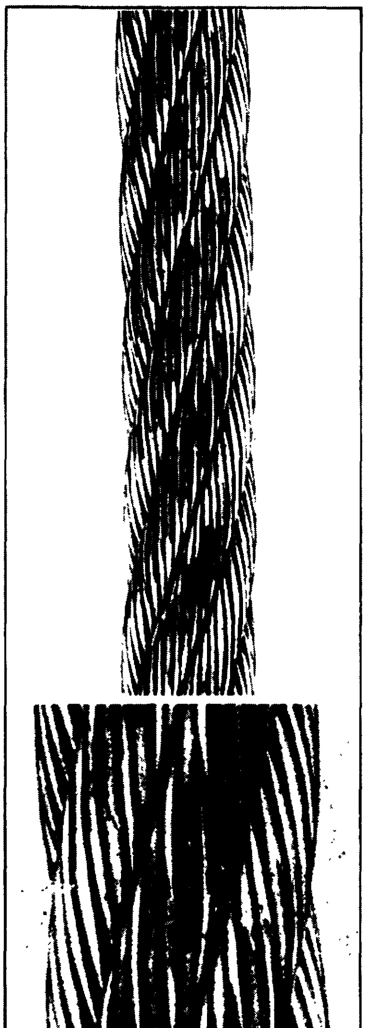
Rope design: Warrington — 1 F + 6 [1 + 6 + 6 + 6]; Wire-ϕ [0,95 0,95 0,95 0,70]

Type of lubrication

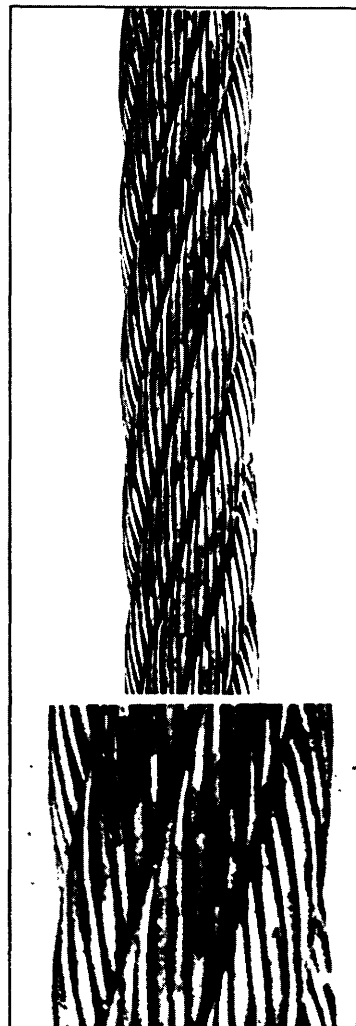
Type of impregnation



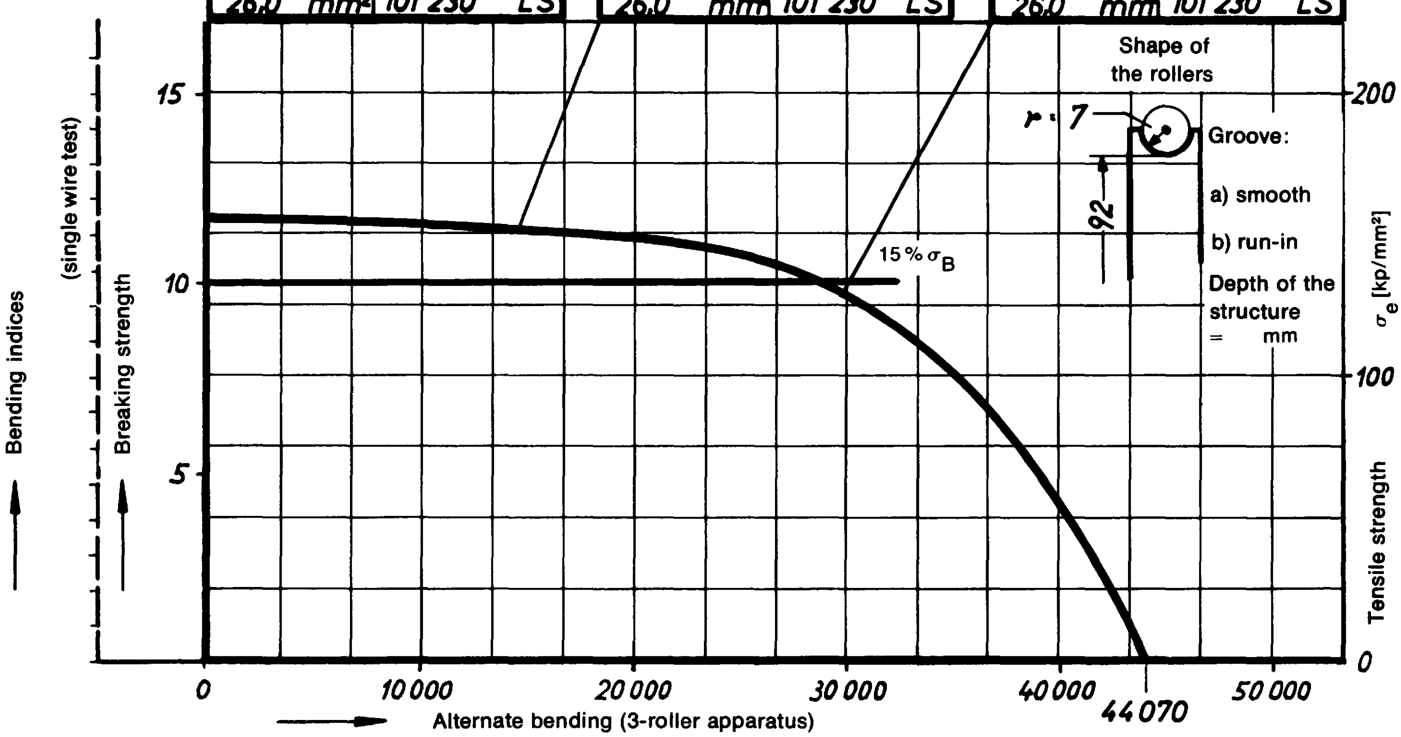
1200 / 1950	kp	
16,0	kp	0 BW
26,0	mm²	101 230 LS



1200 / 1950	kp	9/18
16,0	kp	14 690 BW
26,0	mm²	101 230 LS



1200 / 1950	kp	9/18
16,0	kp	29 380 BW
26,0	mm²	101 230 LS



ANNEX VIII

REPORT OF WORK IN CONNECTION WITH COAL-DUST NEUTRALISATION AND ANTI-EXPLOSION BARRIERS

(Approved by the Mines Safety Commission
at its Plenary Session of 26.4.1970)

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SUMMARY OF WORK IN CONNECTION WITH COAL-DUST NEUTRALISATION AND ANTI-EXPLOSION BARRIERS

Further investigation of the dust and firedamp explosion hazard was felt to be necessary following the Luisenthal disaster, when dust explosions raged through 7.2 km. of roadway despite barriers and wet zones at many points in the mine.

Before setting up a Working Party, the Restricted Committee and the Commission instructed the Secretariat to make a preliminary study to enable attention to be concentrated on certain major practical aspects, including in particular dust control by means of neutralization and of barriers.

One important point to be ascertained was how far the results of experiments hitherto carried out in test galleries of comparatively small dimensions could be extrapolated with respect to the very long and large-section roadways common in actual operations. In addition, the Secretariat was to find out the position in each country regarding means for arresting an explosion in its initial stages, and means for arresting it after it had developed to sizeable proportions over some distance.

A questionnaire on neutralization and barriers was issued to the different countries (Doc. N° 5521/1/63, of November 20, 1963), and a summary compiled of the replies (Doc. N° 4082/64, of June 17, 1964).

The respective positions were briefly as follows:

a) in Britain neutralization only was employed, but the matter had been intensively restudied since 1960 in the light of accidents and of practice in different countries, and the value of barriers had been acknowledged following explosions in which neutralization had proved ineffective;

b) in Italy the view was taken that neutralization was sufficient to halt a dust explosion without barriers as well;

c) in the other E.C.S.C. countries, on the other hand, it was agreed (with some minor variations of opinion on points of detail) that both were necessary, and mines were required or recommended to employ a combination of the two. At the same time it was clear that there was still debate as to the best way of positioning barriers, both main and auxiliary, the choice of type of barrier, where to install them , and so on.

The Commission then set up a Working Party on Combustible Dusts to study the subject, with terms of reference initially laid down in Doc. N° 928/66, and subsequently amended at the meeting on April 24-25, 1967, in line with the Working Party's own views as expressed on February 2.

The amended terms of reference are as follows:

"The Working Party shall study protective measures against dust ignition, with special reference to

1) neutralization (on-the-spot dust control, stone-dusting, water spraying, "laying" by means of salt pastes and coagulants, etc.);

2) barriers (different types of barrier, their construction, positioning, etc.), having due regard to

   a) the mechanism of dust ignition and flame propagation,

   b) factors relevant of the detonation and propagation of the dust explosion such as

      . nature and/or V.M. content of the coal,
      . fineness of the coal,
      . dust concentration,
      . amount of firedamp present,
      . cause of ignition,

. influence of moisture,
. geometry of the roadway,
. etc.

The Working Party may propose any research it considers likely to be helpful in furthering knowledge of the phenomena concerned and contributing to improved safety in this connection."

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The Working Party held its first meeting on February 2, 1967 and after hearing the views of each delegation decided to give priority to the study of stone-dust, water and trigger barriers. Two sub-committees were then set up.

Sub-Committee 1, consisting of representatives of the three countries with substantial experience in this field, was asked to note instructive points suggested by accident reports. From these it could also prepare an aide-memoire for use at future accident inquiries, listing relevant points to note on such occasions, with a view to assembling as much information as possible concerning the performance of barriers.

The Sub-Committee was directed

a) to select typical cases;

b) to consider each incident entirely without reference to the human or personal element or to any aspect relating to responsibility;

c) to deal only with incidents since 1950, except in instances of special relevance.

The rapporteurs were to be Messrs. Hoyle, Hübner and Rebière.

Sub-Committee 2, consisting of heads of testing stations, was to determine the position with regard to

a) knowledge definitely established from past experiments, with particulars of the conditions under which these were effected;

b) experiments in hand;

c) experiments which could usefully be undertaken to remedy existing deficiencies.

Suggestions for future activity should be confined to experiments likely to produce concrete results at an early date, more especially concerning

1) the comparative merits of the Polish and the German type of barrier;

2) the preferability of using several types (heavy, light, intermediate) or only one suitable for all occasions, if available;

3) the minimum distance of the first barrier from the possible point of ignition, and the type of this advance barrier.

The rapporteurs were to be Messrs. Loison, Steffenhagen and Woodhead.

A meeting of the two sub-Committees, presided over by Herr Schneider, the Chairman of the Working Party, was held on June 16. The meeting, which was also attended, in addition to the rapporteurs, by two observers, Messrs. Demelenne and Maas, discussed the various papers requested by the Working Party.

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The Working Party met again on September 22, when it considered the papers prepared by the rapporteurs and drew up a set of proposals and conclusions to be laid before the Commission.

Aide-Mémoire of Relevant Particulars for the Study of Dust-Explosion Accidents (Doc. N° 436/2/67)

The Working Party recommended that the Commission arrange for this document, which it considered to be of value technically, to be circulated in appropriate quarters. It should be borne in mind that

a) the document was not in the nature of an instruction, since it in no way altered the existing national-level obligations in the matter of accident inquiries;

b) it was intended as a guide to assist investigators, who after all had a great many things on their minds at such times;

c) it was to be used by them for reference in assembling particulars which had proved relevant in the explanation of accidents and might form helpful background material for the planning of future study and research work.

Dust Explosions in Germany, France and Britain (Doc. Nos. 4005, 4009 and 4010/67)

Comments on Dust Explosions which have occurred in the Community and in Great Britain (Doc. N° 545/67)

The Working Party proposed that the Commission have these documents circulated in the same way as the Aide-Mémoire. It was to be noted that

a) no accidents prior to 1950 were considered, in view of the changes in operating conditions since then;

b) only accidents both 1) typical, 2) adequately documented and 3) presenting instructive features were considered. Recent accidents still under investigation were excluded. (There had been some typical accidents concerning which adequate information was forthcoming, but also many where the particulars were incomplete: the object of the Aide-Mémoire was to remedy this state of affairs.)

The Working Party further proposed that similar records be compiled and circulated in future with respect not only to dust explosions but also to firedamp explosions (not firedamp ignitions), whether or not barriers came into the picture. These, supplemented in accordance with the Aide-Mémoire, would be sent to the Commission at the same time as the final reports, and could then be circulated at regular intervals (to be fixed by the Commission), with all personal elements expunged.

Bibliography of French Experiments in Connection with Barriers and Control Equipment in the Vicinity of the Workface: Cerchar, M. Loison (Doc. N° 546/67)

Research to Date on Barrier Protection against Firedamp and Coal-Dust Explosions: Dr. Steffenhagen (Doc. N° 7475/66)

Ministry of Power, Safety in Mines Research Establishment: British contribution (Doc. Nos. 723 and 724/67)

The Working Party proposed that the Commission arrange for the circulation of these documents in accordance with the demand in each of the countries concerned.

It was to be noted that they showed the position as at the following respective times of writing:

German paper (7475/66), May 1966;
French paper (546/67), January 1967;
British paper (723/67), January 1967.

Since these dates, however, much important work had been done at the research establishments, which needed to be taken into account as it might affect and would certainly add to the findings recorded. In Germany in particular a large number of explosions had been carried out at Tremonia and the disused Kaiserstuhl pit.

Research was also in progress into the functioning of barriers and the use of extinguishing powders. In addition, experiments were being conducted into possible ways of arresting firedamp explosions.

Draft Study Programme on Barriers (Doc. N° 3243/67)

The Working Party emphasized that this was a schedule of research objectives, not of actual projects.

It considered the programme extremely valuable. It wished to draw the Commissions's attention to the very large number of matters still calling for study, and urged the Commission to take the programme into account in planning future studies.

At the same time, since the research in question would be long and costly and the industry had fallen on hard times, it expressed the hope that the present co-operation among research establishments would be still further intensified in this field where it was so eminently necessary.

Skeleton Framework for Recording Results of Experiments with Barriers. Summary of Work in Connection with Coal-Dust Neutralization and Anti-Explosion Barriers (Doc. N° 3244/67)

The Working Party urged the Commission to recommend this document, which was not intended to be exhaustive but was offered as guidance with a view to securing uniform presentation of the results of future experiments.

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It was observed that, though the Working Party had concentrated more especially on the subject of barriers, a number of other important matters had also been raised; attention had been drawn to the origins of dust explosions, which were very commonly firedamp explosions.

The Working Party recognized that it had not been able to tackle all the points listed in its remit, nor all the points liable to bring about dust explosions.

From the wealth of instructive material before it, its conclusion was that, although in some cases barriers had functioned satisfactorily - which was encouraging for the future - there had also been numerous failures, calling for prolonged further research.

In the present state of knowledge, the Working Party felt it would be premature to submit to the Commission any definite draft recommendations for the attention of managements.

It had at any rate been able to draw an Aide-Mémoire for accident investigators, and to contribute in some measure to closer co-operation among research establishments by drafting proposals for a joint study programme and a joint framework for recording research results.

AIDE-MEMOIRE OF RELEVANT PARTICULARS FOR THE STUDY OF DUST-EXPLOSION ACCIDENTS

1 <u>Location of explosion zone</u>

11 Description of working or workings affected
Designation of seams, workings, cross-cuts.

12 Coal semi-bituminous, bituminous or high-volatile bituminous; volatile-matter content.

2 <u>Working conditions in explosion zone</u>

General information
Explosion occurred during preparatory work in a district, a working, during coal-getting, advancing a heading; workings in operation at time of explosion, workings not in operation.

22 Coal-winnings: working advancing to the rise or on a gradient, advancing or retreating working, method of stowing, length, dip and thickness of coal-face.

23 Transport details, e.g. coal conveyor, roads, stowage material and supplies haulage roads, rail, conveyor or monorail haulage.

24 Types of support used
Cross-section in affected zone, in m^2:

- at the face,
- in the gate-roads,
- in the cross-cuts, etc.

3 <u>Ventilation conditions in explosion zone</u> (1)

31 Main air stream, auxiliary air streams, air streams in the workings and those by-passing the workings, zones of unstable ventilation.

32 Intake airways, return airways
Auxiliary exhaust or forced ventilation.

33 Air quantities in m^3 per min. or sec.
At seat of explosion, in the ventilation district (air intake, air return), at foot of the coal-winning, etc.

34 Air velocity in metres per second
At seat of explosion, in ventilation district (air intake, air return), at foot of the coal-winning, etc.

35 Rate of emission of methane in m^3 per min. For coal-winnings also rate of emission of methane in m^3 per ton of production.

36 Methane content of air stream at seat of explosion.
Results of last measurements before incident in explosion zone (methanometer, flame safety lamp).

37 Any methane accumulations; details of location and amounts of accumulations.
Layers of methane at the roof; details of location and size of layers.

38 Humidity and barometric pressure.

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(1) This information should preferably be supplemented by a plan showing the direction of the ventilation and the quantities of air, the siting of the barriers and zones treated with stone-dust or salt pastes, the points at which the main mechanical and thermal effects were noted, and the positions of the casualties.

381 Hygrometric readings of air in % (or dry and damp temperature).

382 Barometric pressure before and during explosion.

39 Any disturbances of ventilation immediately before incident.

4 Coal-dust in explosion zone and preventive measures supposed to be taken

41 Sources of dust produced: coal-getting machines, shotfiring, falls of coal, etc.

42 Quantity of dust deposited (large, medium, slight):

421 At the foot of the face.

422 In the return airways.

423 In the conveyor and haulage roads (air intake).

424 At the conveyor transfer and delivery points.

425 In the various affected roadways.

426 Degree of humidity of floor, sides and roof of the roadways (dry, damp, very damp).

43 Coal-dust prevention and suppression.

431 Preventive measures supposed to be taken.

4311 At the face: water infusion of the solid coal, spraying, sprinkling of coal-getting machines, etc.

4312 In the affected roadways: sprinkling, spraying, salt crusts, removal of dust by shovel or suction, spreading of stone-dust, salt pastes, etc.

432 Checks before incident to ascertain whether preventive measures under 431 were taken:

- methods of dust sampling and measurement,
- frequency of checks, period since last check,
- place where samples were taken,
- result of checks (quantities of dust, rate of stone-dusting, degree of dampness, etc.).

433 Preventive measures actually taken, as established after the explosion.

4331 In the affected coal-winnings.

4332 In the affected roadways.

5 State of barriers (stone-dust or water) before explosion

51 Methods of barrier construction.

511 Stone-dust barriers.

5111 Main and auxiliary barriers (heavy, light, mixed).

5112 Types of barrier:

- German Dortmund barriers,
- Polish barriers (planks in direction of roadway),
- other types.

5113 Constructional material, dimensions and arrangement of barrier shelves (length, width, position in cross section of roadway).

5114 Description and dimensions of supports and shelf components which ensure their collapsibility.

5115 Number of shelves, distance between shelves.

5116 Type of stone-dust, theoretical maximum loading in kg or litres:

- per metre of shelf,
- per shelf,
- per m^2 of roadway cross-section (state area of cross-section).

5117 Period since last loading of shelves.

5118 Any special features of barriers as actual constructed.

5119 Quantity and quality of stone-dust actually used (effect of humidity).

512 Water barriers.

5121 Description of water barriers.

5122 Theoretical and actual quantity of water.

52 Neutralization zones served by barriers.

53 Position of barriers concerned.

531 Position of barriers closest to seat of explosion, their distance from seat of explosion, from workings, junctions or right-angled bonds in roadways.

532 Location of other barriers, distances between them and distance from roadway junctions.

6 Course and effects of explosion

61 Presumed origin of explosion.

611 Presumed (or most probable) cause of ignition.

612 In the case of explosions started by ignition of methane, presumed volume of methane accumulation or layer.

62 Part played by coal dust.

621 Sources of large-scale dust production or large deposits of dust between seat of explosion and first barriers.

622 Presence and location of carbonized coal dust.

6221 Quantity of carbonized coal dust deposited.

6222 Nature of carbonized deposits: crusts, granula, dust.

6223 Presence of coke beyond first barrier.

63 Mechanical effects.

631 Pressure and blast (stake and dynamic pressures).

6311 Any slow ignition in zone of spread of explosion (without pressure).

6312 At seat of explosion, pressure in kg per cm^2 where this can be calculated or estimated. Direction of blast.

6313 Damage to supports, ventilation doors, materials, transport installations, caused by pressure or blast.

6314 Effect of pressure or blast upon personnel. Pulmonary lesions, serious injuries. Number of persons killed by mechanical effects.

632 Speed of propagation of explosion (calculated or estimated).

6321 In zone of spread of explosion.

6322 Close to barriers.

64 Thermal effects.

641 Roadways affected by flame.

6411 Effects of flame after explosion, e.g. coke, colour changes, scorched material, heatings, smouldering fires, open fires, effects on electric cables.

6412 Places showing signs of persistent combustion of a rich gas accumulation, e.g. heavily charred timber.

6413 Places where signs of medium-scale combustion were observed.

6414 Places where combustion was established by laboratory microscope examinations.

6415 Overall length of roadways affected by flame.

6416 Number of persons burned, number of fatalities resulting from burns at the time or later.

642 Point of extinction of flame and cause:

a) absence of combustible matter
b) natural dampness
c) adoption of preventive measures listed under 431
d) operation of barriers.

6421 Estimated volume of gas presumed to be pure methane which burned.

65 Action of fumes and smoke.

651 Casualties resulting from poisoning in return air of explosion. Number of persons killed and number of persons otherwise poisoned. CO_2 haemoglobin rate.

652 Casualties resulting from poisoning in air intake or other ventilation districts.

6521 Due to explosion penetrating into other ventilation districts. Number of persons killed and number of persons otherwise poisoned. CO_2 haemoglobin rate.

6522 Due to reversal of ventilation. Number of persons killed and number of persons otherwise poisoned. CO_2 haemoglobin rate.

7 Effectiveness of barriers: State in respect of each barrier whether its operation was:

71 Effective (shelves dislodged, flame extinguished within zone of barrier or at a short distance from barrier).

72 Partially effective (shelves dislodged, flame not extinguished and barrier passed by flame, or some shelves not dislodged).

73 Ineffective (shelves not dislodged, although flame passed barrier).

74 Unnecessary (flame was arrested before reaching barrier).

8 General conclusions

81 State roadways in which application of stone-dust, spraying, salt pastes, etc. was effective or ineffective.

A RECORD OF TYPICAL ACCIDENTS DUE TO COAL-DUST EXPLOSIONS OVER THE PAST TEN YEARS, WITH A COMMENTARY

Comments on dust explosion which
occured in the Community and in Great Britain

I - General remarks

The brief notes attached concern accidents in which dust explosions occurred, the accidents themselves being of a nature likely to provide information regarding the effectiveness of stone-dust barriers.

A standard questionnaire has been prepared for the collection of valuable information to be found in reports describing dust explosions. This document comprises questions on the design of a stone-dust barrier, the situation of the barriers in the mine and the part they played during the explosion. Other questions again deal with preventive measures and with ignition sources, and thus go beyond the strict limit of stone-dust barriers. There are, however, two reasons for which it seemed valuable to include them:

- firstly, in order to be able to judge the conditions of effectiveness of barriers, it is helpful to know all the factors which may have affected the intensity of the explosion;

- secondly, the records prepared in this way for the different explosions could subsequently be used for other purposes than the investigation of stone-dust barriers, e.g. to examine the effect of stone-dusting or of salt-paste spraying on the propagation of the explosions.

This questionnaire, in its final form, constitutes the attached memorandum which is to be submitted to the authorities who will have to report on the dust explosions. It is clear that there is no thought of imposing a strict framework on these authorities, our purpose being only to remind them of all the information which it is desirable to provide for each case, because of the value these data may have for a more general investigation of dust explosions.

Among the information collected in this way regarding past accidents, we have noted below the behaviour of different stone-dust barriers situated in the zones affected by the explosions. This makes it possible to group the stone-dust barriers in three categories:

- those which did not function, because the flames stopped for some other reason before reaching them;

- those which actually did halt the flames;

- those which did not stop the flames.

In actual fact, it is sometimes difficult to draw a distinction between the two latter categories. The furthest point reached by the flame can be established only by the presence of observed effects of heating. Hot gases remaining for a fairly long period in an explosion zone may produce effects similar to those of the flame proper when it is travelling very fast. But traces of combustion (and not simply of fusion) are definitely an indication that the flame has passed that point. One must also be very cautious about drawing conclusions from very light objects showing traces of combustion, as these objects may have been carried a long way by the force of the explosion, for example, carbonized coal-dust or small pieces of paper.

On this point, it would be useful to know what has been observed in experimental roadways, and to lay down clearly what should still be studied in order to establish criteria which will make it possible to determine with certainty and in every case the furthest limit of the flame's travel.

II - Explosions in Great Britain

The two dust explosions which occurred in Great Britain are very clear from this point of view. The stone-dust barriers effectively stopped the flames.

1st case - The barrier was situated in a level belt-road 9 m (10 yds) from the foot of a rise heading in the coal, 70 m (76 yds) in length and containing a shaker conveyor. The barrier was of Polish design, of the mixed type, consisting of 10 heavy platforms and 6 light platforms.

Heavy platforms: length 1,80 m (6'), width 0,50 m (1' 8"), weight of untreated limestone dust 135 kg (300 lbs)

Light platforms: length 1,80 m (6'), width 0,35 m (1' 2"), weight of untreated limestone dust 55 kg (120 lbs)

Total weight 3720 lbs (approximately 1.700 kg).

The platforms were spaced at 1,80 m centres. They were set in the upper third of the roadway, which had a cross-section of 5,5 m^2 in the vicinity of the dust barrier.

Before the accident, all the routine analyses showed stone-dust levels above 75 %, but no analysis had been carried out in the rise heading. After the explosion, a sample of dust taken at floor level showed 42,8 % of incombustible matter, while the samples taken from the roof or roadway walls showed from 79 to 96 %.

The explosion was caused by a round of shots fired in the rising roadhead, which ignited an accumulation of firedamp estimated to be 5 m^3 of pure CH_4. In the rise heading the explosion was not very violent, but it was intensified at the junction of the rise heading and the level road. The blast effects were slight, but the stone-dust barrier whose frontage was 9 m further away from this point was completely disturbed.

The flame covered 170 m of the roadway. The clearest traces of combustion were found in the vicinity of the junction. In the level road, towards the heading face, the flame went out of its own accord, the last signs of its passage being some 60 m from the junction. In the other direction, the signs of the flame's passage stopped virtually at the barrier; beyond this point, there was nothing but the wreckage of the stone-dust barrier, slightly charred, and a little carbonized dust on the metal roadway arches.

To sum up, in the case of this relatively light explosion:

- the stone-dusting in the rise heading was not sufficient to stop it,
- as against this, the stone-dust barrier was completely effective.

2nd case - This occurred during a period when all work in the mine had stopped. Several stone-dust barriers were located in the district, only one being affected by the flames; this one had stopped the explosion effectively.

The stone-dust barrier was 225 m away from the heading face in an intake airway. It was a light Polish barrier consisting of 8 2,10 x 0,35 m platforms each loaded with 90 kg of limestone dust (giving a total of 720 kg). The cross-section of the intake airway was approximately 12 m^2, giving 60 kg of dust per m^2. The distance between centres of the platforms varied from 1,35 to 2,25 m. In addition, the roadways were dusted with limestone dust.

Since no work at all was going on in the mine, the origin of the explosion is not known with certainty. It is thought that an electrical discharge caused by a storm caused the ignition of the firedamp which had accumulated in the heading. In the vicinity of the heading face, the mechanical effects were violent (roof falls had occurred). The stone-dust barrier, situated 225 m away, was completely upset. As against this, another light barrier - of German design and comprising 4 platforms, situated 390 m from the heading face - remained almost intact. It was also observed that violent effects had occurred in two cross-cuts linking the heading faces of the parallel intake and return airways. A barrier in the return airway had been partially upset.

The flame went only 20 m past the first barrier in the intake airway. Beyond this nothing was found but coke-dust. The flame did not penetrate into the return airways but stopped in the cross-buts.

The fact that dust was involved in this explosion is quite certain, but it was not predominate. The stone-dust barrier acted effectively.

III - Explosions which occurred in Germany

In Germany stone-dust barriers are built according to the Dortmund regulations. In the examples investigated certain stone-dust barriers were effective and others were not.

Pit A - The accident appears to have been due to the ignition of firedamp emitted in consequence of ground movements, the source of ignition being a heating behind the lagging. Two stone-dust barriers situated one on each side of the ignition point, respectively 10 m and 50 m away, did not stop the flame, and this was doubtless due to the fact that the explosion had not yet attained a sufficient degree of violence. As against this, a further stone-dust barrier failed to stop the explosion which by now had become too violent. One barrier acted effectively and others were not involved, since the flame was stopped before it reached them.

Pit B - The explosion was caused by a round of shots fired in a heading, which was closed off by a pressure-resistant barrier 327 m from the heading face. A secondary stone-dust barrier was 140 to 150 m from the heading face and a main stone-dust barrier at 270/300 m. The most marked mechanical effects were observed from the point 185 m from the heading face up to the barrier. Between the heading face and the barrier there were signs of heating effects. The thermal and mechanical effects hardly managed to pass the barrier, although a gap had been left open in the latter (the victims died of poisoning). The stone-dust barriers were upset, no firedamp was present, and the explosion was due solely to coal-dust.

Pit C - Here again the explosion was caused by a round of shots fired in a heading. A secondary stone-dust barrier was sited 90 m from the heading face. The flame, stopped by the barrier, did not exceed 110 m. There were four other stone-dust barriers in the same road at intervals varying from 40 to 100 m. Out of a total of 44 platforms, 35 were upset, but the flame did not reach as far as these barriers.

Pit D - The source of ignition was a heating in a goaf, whilst the mine was idle. One stone-dust barrier in a top road was not reached by the flames. In the bottom road the flame travelled a distance of 40 m. A secondary barrier situated at the point was not considered to have been affected.

Pit E - The explosion occurred at the foot of a rise heading, driven in the seam from a cross-measures drift. The rise heading was undoubtedly full of firedamp after a stoppage of several weeks' duration.

The ignition may have been due to an impact or to friction. There were two stone-dust barriers in the cross-measures drift, one on each side of the entry to the rise heading; the secondary barrier was situated between 36 and 52 m away, and a major barrier between 134 and 166 m. The thermal effects were noticeable over a distance of 83 m on the side towards the secondary stone-dust barrier. There is doubt as to whether dust was involved in the explosion, but if it were then the barrier would seem to have operated effectively.

Pit F - In this accident, the flame reached 33 major stone-dust barriers and 3 secondary barriers.

The barrier nearest to the explosion did not function, as the explosion started from a long layer of firedamp, some 10 cm thick, lying behind the supports under the roof.

The explosion covered 4.800 m of roadway, slowing down several times but then continuing with renewed violence. The authorities carried out a very precise investigation of these phenomena, determining the position of each stone-dust barrier before the explosion and its influence on the development of the explosion. This study showed that:

- 10 stone-dust barriers functioned properly. There may have been some traces of heating or the passage of a blast of hot air beyond these barriers, but the flame did not go very far past them.

- 5 major barriers and 2 secondary barriers did not function effectively; of these:

  - 3 major barriers and 1 secondary barrier were doubtless not sufficiently loaded with stone-dust.

  - 2 major barriers and 1 secondary barrier were not able to function because of the excessive speed of the explosion.

- 1 stone-dust barrier did not act effectively because of the presence of a firedamp layer in the roof (this was the layer which caused the explosion).

- 17 major barriers and 1 secondary barrier were not involved since the flame was extinguished before it reached them (e.g. because of the presence of moisture).

Normally the roadways were stone-dusted, but this was found to be either inadequate or ineffective.

Pit G - The explosion was due to the presence of a firedamp layer 30 m long, which was ignited by a round of shots fired during heading a bottom road which was 70 m ahead of the face. The secondary stone-dust barrier at the entrance to the fast end near the face did not function effectively, either because the quantity of stone-dust was not sufficient to extinguish the flame or because the explosion was too weak. As against this, 2 major stone-dust barriers in the bottom road functioned properly. The explosion passed through the face, and 2 other stone-dust barriers were not able to stop it in the top road, undoubtedly because of the large cross-sectional area of the roadway. It was the moisture in the top road beyond the stone-dust barriers which extinguished the flame.

Pit H - When a fan in a rise heading was switched on after being stopped, methane became concentrated in a cross-measures drift carrying a trolley-loco line. The firedamp ignited when a locomotive passed the point. There is no doubt that the degree to which dust was involved was only slight. Three stone-dust barriers were situated in the cross-measures drift, one 150 m away towards the intake airway, the two others respectively 450 and 500 m away from the return airway side. All three functioned. On the intake airway side, the flame extended only 3 m beyond the stone-dust barrier.

The investigation of these eight dust explosions which occurred in Germany produced various results in respect of the efficacity of stone-dust barriers as a means of halting explosions.

In pits C - E - H the system of inert stone-dust barriers functioned perfectly satisfactorily. These accidents can therefore not be used to draw any special conclusions. In other instances, the explosion was stopped by the stone-dust barriers, but certain barriers did not function at all or functioned only partially (pits A - B - D - F - G). The failure of the barriers was not always discovered. The flame passed certain stone-dust barriers because they were too near the point of ignition starting the explosion. In this case, the explosion, being in its initial stages, probably did not produce pressure necessary to upset the barriers (e.g. pits A - D and F). In the case of other barriers, the fact that the roadways were of large cross-section (over 10 m^2) contributed to their failure (pits F and G). For some of the stone-dust barriers, the quantity of dust was insufficient to extinguish the flame, so that it was not halted although the barrier was upset (e.g. pit F). Finally, some barriers did not act effectively, probably because of the inert dust was not suitable, either because of some human error or because of the climatic conditions in the pit (e.g. pit F). In none of these cases could it be demonstrated that stone-dusting on top of the coal-dust to bring the combustible matter content below 50 % had achieved its purpose.

To sum up, it can be concluded from these facts that the system of stone-dust barriers normally used hitherto in Germany, and the process of stone-dusting, are both faulty. The stone-dust barriers did act as a good means of halting the explosions of coal dust. But past explosions also teach us that stone-dust barriers are not an infallible measure. It is not satisfactory to have observed that stone-dust barriers act in a reasonably predictable manner, but not with complete regularity. In consequence, the system of barriers using inert dusts should be improved and extended, so as to present the maximum probability of avoiding failure. The following suggestions are advanced to this end:

1) Increasing the number of barriers in gate-roads

Up to the present, German regulations have prescribed only a single stone-dust barrier in each gate-road. Now an increased number of barriers in gate-roads is considered necessary, as soon as the roads exceed a certain length (the barriers being set at prescribed intervals). It is proposed that a second stone-dust barrier should be added once the distance between the face and the first stone-dust barrier exceeds 200 m, and that further barriers should be installed every 500 m where the gate-road reaches a length of 500 m or more. This arrangement is suggested to eliminate the possibility of an explosion reaching a speed which is too high for the barriers to act effectively, because of the excessive distance between the first stone-dust barrier and the centre of the explosion, or an excessive interval between two stone-dust barriers. In addition, this guarantees that other stone-dust barriers are situated in the roadway, in cases where the first stone-dust barrier is situated near the centre of the explosion and the flame is able to pass it, because, being in its initial stages, the explosion has not built up sufficient pressure to upset the barrier. The increase in the number of stone-dust barriers seems to be particularly necessary once the roadways have a larger cross-section than used to be the case.

2) Application of plastic platforms instead of wooden platforms

Permission should be given to use platforms made of plastics in place of wooden platforms, in the construction of stone-dust barriers, provided that these platforms have been subjected to the necessary tests. This would make the erection of stone-dust barriers easier, and would ensure better dispersion of the dust because of the way in which they are destroyed when the barrier is upset. Naturally, these substances should not, when heated, emit toxic gases which cannot be dealt with by self-rescuer filters.

3) Installation of water barriers instead of stone-dust barriers

Pits should be left free to use water barriers instead of stone-dust barriers. However, in one particular road or district only one sort of barrier should be used. Water barriers should be set in gate-roads at intervals of 200 m.

Water barriers completely eliminate the climatic problems which are caused by the humidity of the air. In addition they do away with human errors because it is so simple to inspect them. Moreover, the use in water barriers of vessels made of plastics makes them easier to erect and increases their effectiveness.

4) Use of the salt-paste method

Since stone-dusting of mine roadways does not eliminate the danger of coal dust explosions, the salt-paste method should be used more widely. This method makes it possible to immobilize the coal-dust with a high degree of certainty. The return airways from faces should be treated with salt-paste over their whole length. On the intake airway side of the workings, it is advisable to have properly-treated salt-paste zones of about 150 m in length, since less dust is deposited on the intake airway side.

IV - Explosion which occurred in France

Two accidents were given special attention. Other dust explosions occurred in the French mines, but provided no information on the effectiveness of stone-dust barriers. In fact, there were either no stone-dust barriers at all or the flame did not reach those which were present.

Accident No. 1 - The origin of the ignition is said to have been a compressed-air blower in the upper part of a face where there might have been a small accumulation of firedamp. However, dust played the predominant part in the explosion. Eight stone-dust barriers were upset.

The first stone-dust barrier in the return airway from the face was 180 m away. Thermal effects were observed up to the point where a roof fall had occurred, 60 m behind the stone-dust barrier, and were especially marked between the barrier and the fall. Beyond the fall, there was a stretch of roadway of some length without any signs of burning. In particular, a barrier 420 m from the top of the face had been upset in the direction towards the return airway without any signs being found that a flame had reached that point. On the other hand, the thermal effects show themselves again in the vicinity of the junction with another return airway 500 m from the top of the face.

It has been assumed that the hot explosion fumes were still combustible and reignited when they encountered the oxygen-containing air in the other return airway. If this explanation is correct, it will be necessary to examine the cooling effect which stone-dust barriers seem to have.

In the bottom road to the face, the thermal effects were very marked but they stopped well before the first barrier, at 160 m from the bottom of the face. It would seem that the explosion was stopped by the stone-dusting there.

Accident No. 2 - This explosion was certainly caused by shot fired in the heading in a bottom road, 30 m ahead of the face. In essence, this was a dust explosion, possibly locally reinforced by small quantities of firedamp.

In the bottom road, there was a secondary barrier situated 100 m from the heading face. The thermal effects were not very marked up to the barrier and were even less clear beyond it. The platforms constituting the barrier were upset, but had not been seriously damaged and some were even still hanging in place. The explosion in the bottom road cannot therefore have been very violent.

In the face, there were no mechanical effects and the thermal effects were slight. In the top road, there were only slight traces of heating. Some signs were found in a cross-measure drift in which the top road terminated; the mechanical effects were fairly violent here. In this cross-measures drift there was a barrier 165 m from the top of the face (1 bend in the road) or 340 m from the starting-point of the explosion. The thermal effects stop before the barrier, which was supplemented by a stone-dusted zone containing between 88 and 93 % of inert material. This barrier was smashed.

It would seem therefore that on one side the flame was stopped by the first stone-dust barrier and on the other side before it reached the first barrier. However, clear traces of combustion were observed in the vicinity of the district loading-point, towards the intake airway, 140 m beyond the barrier in the bottom road (paper bags, notebooks, cloths). Moreover, 4 of the victims killed were in this zone and their bodies were badly burned. The question therefore arises as to what is the real part played by the barrier, since places of combustion were observed well beyond it ? Perhaps the explosion was too weak ?

V - Conclusions

There is no doubt that detailed investigation of accidents can provide useful information. The very full reconstruction of events worked out after the disaster at Luisenthal shows that such an investigation is very valuable. Unfortunately, it is not a very simple matter because the information available to determine the cause of the explosion comes from only a few signs (mechanical and thermal effects) and because the situation before the accident is not always known in detail.

In particular, it is frequently difficult to draw a distinction between the effect of firedamp and that of dust in an explosion. The presence of a few particles of carbonized dust is not sufficient to support the conclusion that dust was involved, since it is quite usual for the firedamp flame to cause partial distillation of such particles.

Moreover, one sometimes hesitates to express an opinion regarding the effectiveness of a barrier. In fact, in certain instances when the flame is halted in the vicinity of the barrier, the question arises as to whether this halt was brought about by the barrier or by some other cause, since there are a number of factors which can bring about a slowing down of the explosion (bends in the road, variations in cross-section, variation in the quantity and quality of deposited dusts, variation in the intensity of stone-dusting).

In other cases the thermal effects, or even the traces of combustion, have clearly gone well past the barrier or reappear at a certain distance beyond that barrier. Here the question arises as to the true effectiveness of the barrier and as to the conditions in which the fumes were cooled down by the inert dust discharged by the barrier.

Numerous investigations carried out in experimental roadways have certainly provided valuable information regarding these phenomena, but it is advisable to bring them together to make fuller use of them in examining the actual accidents. Moreover, the complexity of the phenomena which occur during accidents of this kind is such that the conventional tests in experimental roadways represent conditions only imperfectly. This is what gives value to certain new experiments which have been very carefully prepared, in spite of their high cost (e.g. in abandoned pits) in order to reproduce conditions as close as possible to those in actual collieries.

BIBLIOGRAPHICAL NOTES ON RESEARCH WORK CARRIED OUT ON BARRIERS IN THE COMMUNITY COUNTRIES AND THE UNITED KINGDOM

State of the research into protection by safety barriers against explosions of firedamp or coal-dust

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1. Introductory remarks

At the meeting in Luxembourg on the 2nd February, 1966 of the Working Party on "Inflammable Dusts" of the Permanent Commission on Mines Safety, one particular decision taken was that it was necessary to bring together and make full use of the work carried out by research institutes in the field of safety barriers against explosions. To this end, the present document reports on the research carried out and the experience gained by the research institutes of West and East Germany, as well as those of Austria, Czechoslovakia and the United States of America. Illustration of the text is not envisaged at present.

The report covers the period from the beginning of this century to the end of 1965. For the sake of clarity we have omitted those research projects which are of historical interest only, as well as all details of secondary importance. The author asks the reader who wishes for further details to refer to the publications listed in the Bibliography at the end of this report, the items in which are identified by numbered references in the text. The origin and development of explosions, as well as the multiplicity of factors which determine the character of an explosion, have been dealt with only to the extent that they are directly related to the effectiveness of safety barriers.

It is necessary to point out that this report deals solely with safety barriers, out of all the anti-explosion measures which are applied in collieries. The prevention and elimination of accumulations of firedamp, dust suppression in the winning and transport of the coal, measures to neutralise the deposits of coal dust by stone-dusting, by wetting or by hygroscopic salts are not dealt with in this document.

However, it does seem necessary to conclude these introductory remarks by saying that, taking into account the body of results obtained from the research work completed hitherto and that obtained from the practical experiments, none of these measures is sufficiently effective to make the conventional safety barriers unnecessary, let alone superfluous. This holds good for the deep mines where the coal is won and transported by the normal European methods. A different judgment may be justified in pits where the working conditions are entirely different, as e.g. in the United States.

2. Research carried out in the German Federal Republic

2.1. General remarks

Taking as a basis the trials carried out and safety measures applied in the French, British and American pits, German researchers started at the beginning of the century to investigate the effectiveness of anti-explosion barriers in coal mines (1,2,3). The first tests were carried out on the surface, in long steel tubes. Beyling reported on this work in 1919 (4). In order to be able to perform these experiments on the industrial scale, the experimental mine - located at the time at the Hibernia pit at Gelsenkirchen - was brought into service in 1927. The decision to set up the experimental mine was taken when it became clear that the mine was necessary to make it possible to reproduce explosions in roadways in the conditions actually met with in European pits, with natural transmission of the heat from the surrounding rock and in the conditions of pressure and relaxation which occur when a shock wave is propagated at great depth in underground workings of considerable length and of relatively small cross-section (25).

Since 1942, the Versuchsgrubengesellschaft mbH at Dortmund used the Tremonia pit for its trials and, of recent years, has also been able to carry out many explosion tests in other uneconomic pits which have been closed.

Up to the end of 1965, approximately 600 full-scale explosion tests were carried out within the framework of the investigation of safety barriers.

The conditions of these tests were very diverse, and were varied over a wide range; one variable was not modified, so as to maintain comparability, i.e. the type of coal-dust used for the trials. Use has always been made hitherto of a standard dust known as "standard Derne dust", i.e. a bituminous coal-dust containing approximately 25 % of volatile matter, with an ash content of about 5 % (more recently with variations in ash content up to 14 %) and a size analysis such that 93 to 96 % passes through a 0.075 sieve (DIN 1171).

While the explosion tests carried out over the last few decades were primarily concerned with trials of stone-dust barriers, in the last three and a half years the emphasis has been on the investigation of water barriers. Dust barriers are now used only for purposes of comparison.

Research in the field of measures against firedamp and coal-dust explosions has not yet completely explored the whole field. We do not as yet have enough information on certain questions of detail.

2.2. Stone-dust barriers

2.21. Present research results

2.211. Effectiveness of stone-dust barriers against firedamp explosions proper

The term "firedamp" is applied to an explosive mixture of mine gas methan (CH_4) and air. At normal temperature and pressure, the explosive limits of this mixture lie at approximately 5.5 - 15 % CH_4.

The stochiometric mixture which causes the most violent explosions contains 9.5 % CH_4. The results given below in general to firedamp with a CH_4 content of 9 to 10 %, as long as there is no explosion of the layers of gas near the roof obtained by the introduction of concentrated firedamp into the explosion chamber.

Theoretically, a barrier can produce a genuine extinction effect on an explosion only if it is reached by the shock wave which precedes the flame, and struck sufficiently strongly and early enough to ensure that the material with which the barrier was filled forms a sufficiently dense cloud in the roadway. The ignition of a firedamp mixture is propagated so rapidly - at the speed of a detonation - from one molecule of gas to another that it cannot be stopped by a dust barrier. This was shown by earlier tests, which also convinced us that no type of barrier can prevent the combustion of all the gas present.

It is for this reason that a barrier completely enveloped in an accumulation of gas will always be ineffective if the gas is ignited and can never prevent the propagation of the explosion.

The effect is different when the barrier lies outside the zone where the gas has accumulated but is still within the area traversed by the flame following the explosion when it undergoes its normal expansion, which corresponds to a multiple of the initial volume of the gas. In this case, the time which elapses between the moment when the shock wave reaches the barrier and the moment when the flame reaches it may be sufficiently long to allow adequate dispersion of the material with which the barrier is filled across the roadway, so that the dispersed material can offer to the flame a degree of mechanical resistance sufficiently high to cause considerable shortening of the latter. In this case, too, all the gas will burn, but the shortening of the flame will make it much less likely that the explosion will be transmitted to the coal-dust. From this point of view, the barrier also offers a certain degree of protection against firedamp explosions proper.

This partial success had been duly confirmed by a series of trials (24, 25, 27, 33).

2.212. Protection against coal-dust explosions by means of stone-dust barriers

2.2121. Fundamental data regarding the operation, design and types of stone-dust barriers

The initiation of a coal-dust explosion requires a much more intense heat source than the explosion of a concentration of firedamp. Whereas a spark is sufficient to set off a firedamp explosion, coal-dust becomes ignited only when it is in a cloud and when this cloud is affected by a shotfiring flame, an electric arc or a flame emanating from a firedamp explosion.

The possibility of restricting the spread of a coal-dust explosion by means of a cloud of stone-dust is much greater than is the case with the firedamp explosion; the phenomenon in question is not one of the propagation of ignition from one molecule of gas to another, but the transmission of the ignition of one coal-dust particle to another by radiation, which can be screened off when a particle of stone-dust forms a barrier interposed between the particles of coal (20, 25). In addition, a cloud of stone-dust cushions the shock wave which - by reason of its laminar and turbulent flow - stirs up and maintains a cloud of coal-dust in front of the flame. However, in order for a dust barrier to be effective, the shock wave ahead of the flame must be sufficiently strong to tip over the platforms forming the barrier and to produce a dense cloud of the material filling the barrier, and for the shock wave to be ahead of the flame of the explosion by an appropriate time interval. When this time gap is too small, the stone-dust is not able to form a sufficiently dense cloud before the flame arrives; when the time gap is too large, a considerable portion of the stone-dust can already have settled on the floor by the time the flame arrives, and the effect is therefore not strong enough.

It frequently happens during the tests that the flame is extinguished only a considerable distance behind the barrier because the stone-dust is carried along by the explosions shock wave and is unable to form a dense cloud until some way beyond the zone where the barrier is situated. But in a case such as this it can also be argued that the barrier is in fact totally effective; if a sufficiently long observation zone is arranged beyond the barrier, it can be observed in each case whether the flame was stopped by the stone-dust or whether it became extinguished because it was no longer kept supplied with coal-dust. Each explosion pushes before it a sufficiently large quantity of coal-dust for the flame - in the event of failure of a stone-dust barrier - to become propagated considerably further than when the stone-dust acts effectively some distance beyond the barrier zone.

Since 1926, stone-dust barriers have been obligatory in German pits. The location and design of these stone-dust barriers is governed by the information available. A certain number of fundamental ideas will be described here, an examination of the details being made in the subsequent chapters.

A stone-dust barrier cannot exert its full effect except at a certain distance from the ignition point, when the shock wave ahead of the flame has become sufficiently strong to tip the barrier over. Since the whole of the shock wave must reach the barrier, allowance may be made when siting the barrier for the local conditions, e.g. marked variations in roadway cross-section, curves, roadway junctions. It is necessary to ensure that the fittings installed in the roadways do not hinder the free dispersal of the stone-dust on the barriers. Since it may happen that an explosion traverses a zone protected by a barrier, the measures against explosions must be based on a system comprising several successive barriers at certain intervals.

In addition, it has been found advisable to set up barriers to isolate certain districts from each other to prevent the propagation of an explosion.

For this purpose, the workings are grouped in ventilation districts. Apart from this, the main shafts, the preparatory roads in the stone and in the coal, and the different workings in a winning district, are protected by barriers (12, 36) (1).

As regards the construction of the barrier, it has been observed in the past that it is very important that a blast of air should be able to cause the free dispersal of the stone-dust. Box-type dust containers have not given good results. Previous trials with platforms heavily loaded with dust failed (24, 25). The effectiveness of the barrier is all the more reliable the easier it is to tip over the barriers. It is important to find in each case the best solution, which allows of storing the necessary quantity of dust in the available (and often restricted) section of roadway on platforms which are as light as possible.

2.2122. Varying effectiveness of stone-dust barriers as a function of the pressure and the speed of propagation of the explosion

We give here some general information on the relationship existing between the effectiveness of the barrier on the one hand and the pressure exerted by a coal-dust explosion and the speed of propagation of the flames on the other. Detailed examination of this question has been kept for later chapters in this report, as there is a close relationship with other experimental conditions (minimum distance of the barriers from the ignition point, type of barrier, geographic and technical conditions), for which reason it is necessary to reproduce the experiments using explosions which have different pressures and speeds of propagation.

2.21221. Explosions of average intensity

The boundaries between coal-dust explosions of weak, average and great intensity are not at all clear, so much so that it is possible only to give approximate numerical values to define them. Explosions of average intensity exert an air pressure (dynamic pressure) lying between 200 and 400 p/cm^2 (2), and are associated with a static overpressure (on all sides) of between 1.5 and 3 kgp/cm^2, while the speed of propagation of the flames is generally of the order of magnitude of the speed of sound (330 metres/sec). With such explosions, it has been observed that the probability that the barriers will be of maximum effectiveness is particularly high. The air pressure is constantly sufficiently great to tip over the barrier and to cause good dispersion of the stone-dust in the roadway. Similarly, the interval of time between the shock wave and the point of the flame is, in such explosions, most frequently between 0.1 and 0.2 seconds, so that it is neither too long nor too short to guarantee that the dust cloud has a satisfactory effect on the flame (33, 37).

2.21222. Very weak explosions

In the initial stage or after considerable attenuation, coal-dust explosions frequently produce an air pressure of no more than approximately 20 to 100 p; the static overpressure is frequently below 1 kgp/cm^2, and the speed of propagation of the flames of the order of 100 metres/sec (it is difficult to take precise measurements in the initial stage). In the extreme case, the phenomenon is restricted to a deflagration with no appreciable pressure phenomena associated with a speed of propagation of the flames of only some 10 metres/sec (26). The observations have shown that not only the accumulations of firedamp (layers at the roof) but also the coal-dust whirled up by a current of air can burn relatively slowly over a certain distance.

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(1) When mention is made of the regulations of the Dortmund Chief Mines Inspectorate, the regulations apply, with due allowance and with certain unimportant modifications, for all the pits in North Rhine/Westphalia and the other Länder of the Federal Republic.

(2) Translator's Note: p = pound.

The weak explosions referred to here have been studied with particular attention in recent years in the Federal Republic of Germany (29, 35, 37, 38, 39).

These explosions give rise to particular difficulties in respect to the use of barriers, difficulties which have not yet been completely overcome. This problem is worthy of continued study, since when making the effort to apply effective preventive measures in the initial stages of an explosion, allowance must be made for the fact that a short way away from the ignition point the pressure and speed of propagation of the explosion are still very low.

Trials with dust barriers using very weak explosions have given divergent results, without making it possible to determine the causes of the failure in each individual case. The general conclusion hitherto obtained is that with very weak explosions one cannot be as sure as is the cause with stronger explosions that the barriers will provide the desired effectiveness, if the blast of air does not exert the minimum pressure necessary to tip over the dust platforms and to provide adequate distribution of the extinguishing substance, so that the barrier fails to be effective and the flame can be propagated beyond the barrier zone.

2.21223. Very heavy explosions

A powerful initial effect, e.g. the ignition of a large quantity of firedamp, or on the other hand a long "run-up" path and the presence of a substantial quantity of coal-dust are conditions which can give rise to a very powerful explosion. In certain trials of explosions of this type, air pressure of as much as some 1 kgp/cm^2, and static overpressures of as much as 8 kgp/cm^2 and flame-propagation speeds of more than 1000 metres/sec were observed. It became clear that the stone-dust barriers are ineffective against such powerful explosions (25, 27, 28, 33, 35). The barriers were not effective with flame-propagation speeds of 600 metres/ sec and over. It has been impossible to date to establish with any degree of accuracy the position of the precise limit of effectiveness of stone-dust barriers. The observations made seem to show that in the case of such heavy explosions the time interval between the shock wave and the tip of the flames becomes smaller and smaller until it falls below 0.1 second, or even to only a few microseconds, so much so that the stone-dust barrier is, it is true, tipped over but can no longer produce sufficiently quickly the cloud of dust necessary to cause extinction of the flame.

Another explanation could be that, when intense explosions occur, the mechanical resistance of the cloud of dust is not sufficient to prevent the flame traversing the barrier zones.

2.2123. Minimum distance between the stone-dust barriers and the possible point of ignition

Numerous tests have been carried out in recent years to determine the distance from the point of ignition at which the shock wave from an explosion can trip a stone-dust barrier (27, 29, 37). The results were inconclusive; it will probably be impossible to establish a precise figure for the distance. In general terms, it may be assumed that a stone-dust barrier can halt an explosion if it is situated at least 50 metres from the ignition point; numerous cases of failure of stone-dust barriers have been recorded where the distance has been less than this. Coal-dust explosions which are weak at the beginning frequently require a distance of 60 metres to build up a sufficient intensity to cause the stone-dust barriers to be tipped over. The very important point in this question is the fact that a coal-dust explosion may have a low initial potential (e.g. a firedamp explosion beginning with a simple deflagration) or a powerful initial impulse (e.g. a heavy firedamp explosion or the firing of a shot causing ignition).

It is necessary to settle whether one can expect in practice that the firedamp will be ignited or whether direct ignition of the coal-dust suspended in the air will occur. In German pits, it is considered that the ignition can occur at any point in a working where coal is won or transported. The most threatened zone comprises the winning workings and the extremities of the gateroads.

When an explosion which takes place in a winning district becomes propagated into the gateroad, it loses part of its energy as a consequence of the change in direction and normally has to cover a certain distance along the gateroad before recovering sufficient energy to tip the safety barrier over. An explosion which occurs at the heading face in a gateroad also has to have a certain "run-up" distance. This is why it is recommended that a certain interval should be maintained between the foremost dust barrier and the points where the winning workings open into the gateroads. The old regulation of the Dortmund Chief Mines Inspectorate laid down a distance of 25 metres (12). The new regulation stipulates a minimum distance of 50 metres and a maximum distance of 150 metres to guarantee, as far as possible, that the foremost barrier is affected by the explosion. In addition, the new provisions require the installation of anti-explosion barriers every 200 metres in roads leading to faces and every 400 metres in other roads (36).

2.2124. The importance of local conditions

It is only recently that it has been observed that the cross-sectional area of the roadway has a considerable influence on the effectiveness of the barrier. The precise information obtained on the effectiveness to the dust barriers during the tests carried out in the Tremonia experimental mine, in roadways with a cross-sectional area of 8 to 10 m^2, remained partly unconfirmed when similar trials were carried out in roadways with a cross-sectional area of 12.5 m^2. Here the pressure and the speed of propagation of an explosion of coal-dust once again become of decisive importance.

There is no reason to doubt the effectiveness of dust barriers in the case of explosions of average intensity, even in workings with a considerable cross-sectional area. During trials with very weak explosions, it was however noted that the dust barriers in roadways of 12.5 m^2 cross-section did not always fulfil their task, whereas the trials carried out in identical conditions in the 8 to 10 m^2 cross-section roadway at the Tremonia experimental mine were always successful (37).

From this one may deduce that when the shock of the very weak explosion tips over the dust barrier without causing sufficient dispersion of the sterile dust, the flame which follows behind the shock wave can pass through the barrier zone more easily in a roadway of large cross-section than in a smaller one. It goes without saying that in a roadway of large cross-section the flame can more easily "push its way" through the dust cloud than in a narrow working. It is for this reason that the results obtained in the experimental roadways of small cross-section or in steel tubes can be applied only with considerable reservation to the normal type of roadway found underground nowadays, with a cross-section of 12 m^2 and more. As against this, there is much less risk of committing an error in assuming that information obtained during trials carried out in large roadways is equally applicable to small-section roadways.

Another problem which has for a long time preoccupied the experimental pit is the propagation of coal-dust explosions along paths where they encounter major variations in seam thickness, curves, crossovers and forks etc., bearing in mind the consequences with regard to the effectiveness of stone-dust barriers. Up to the present it has not been possible to carry out a large number of trials of this kind in actual conditions. There is every reason to think that explosions are little affected by curves which involve a change of direction which may be as much as 90° in roadways of constant cross-section, and that no appreciable reduction in pressure or in speed of propagation is brought about. It must be expected that there will be a considerable weakening of the force of the explosion at forks and crossovers.

On the basis of the data obtained, a subsequent recommendation of the experimental mine laid down that stone-dust barriers should not be installed less than 25 m from curves or crossovers (25).

The regulations of the Chief Mines Inspectorates (Dortmund) dated 1/7/53, and still in force, laid down that stone-dust barriers must not be installed at crossovers in roadways, nor at curves or other points where - as had been found from experience - the shock wave of the explosion may be weakened to such an extent that the barriers are not affected. In principle it is necessary to have a rectilinear section 75 m long up to the point where the barrier is set (17). The new mining regulations lay down that anti-explosion barriers must be installed at a minimum distance of 50 m and a maximum of 75 m from forks and crossovers in roadways (36). This stipulation is the one which is closest to the information obtained by trials in the meantime.

2.2125. Effectiveness of different types of stone-dust barrier

During the last few decades, the experimental mine has tested a number of stone-dust barriers of different types (4, 24, 25). Some of the fundamental experiments carried out in this field have already been referred to (2.2121.). The essential principle discovered is that there must be no hindrance whatsoever to the free discharge of the stone-dust. Neither box-type containers nor planks with low borders have proved satisfactory (25, 27).

Developments have been marked by the fact that planks carrying a heavy load of dust were replaced by lighter designs - in the light of the test results - without losing sight of the need of limiting the barrier zone to a short section of roadway. The results was the combination of heavy and light dust-carrying structures made of planks, as laid down in the Dortmund Chief Mines Inspectorate directives of 1/7/53 (17). These instructions envisaged the use of "main barriers" with a load of 400 kg of stone-dust per m^2 of roadway section and "secondary barriers" with 100 kg/m^2. New measures by the Dortmund Chief Mines Inspectorate, modified in a number of respects, and dated 21/11/65 (40), are touched upon in the present report only insofar as it is necessary to mention the new information obtained by the research which led to modification of the official directives.

(Practical results from the trials carried out with the new types of modified barrier became available only from the beginning of 1966 and have not yet been included in the present report.)

With the experimental explosions, the stone-dust barriers were regularly employed as "main barriers" with a load of 400 kg/m^2 and designed, in accordance with the regulations, as "Dortmund platforms" intended for a maximum charge of 300 kg and as "platforms" consisting of a single plank capable of carrying a charge of 100 kg of dust, the latter being arranged in twos or threes at the beginning and end of the barrier (17). Experience having demonstrated that "secondary barriers" with a charge of 100 kg/m^2 of roadway cross-section were not reliably effective, the new instruction no longer provides for this type of barrier and lays down a charge of 400 kg/m^2 for each barrier (40).

Tests carried out recently with a Polish type of barrier (29), for the sake for comparison with the German type (Dortmund platform) were of particular interest. The two types differ by the position and length of the planks and by the type of platform support. During the trials, the Polish platform was found to tip over more easily than the Dortmund platform, although less easily than a single-plank single-support platform. The single-plank platform with two supports and the Polish platforms behaved in the same manner with the same weight of dust. The Polish barrier seems to react slightly more easily to very slight explosions. The length of the supports used for the platform also ensure that there is slightly more clearance in the roadway. The new German regulations (40) allow of two types:

a) Type 1 corresponds in principle to the older type of barrier made up of "Dortmund platforms", and consists of heavy platforms (carrying a charge of 150 to 300 kg and having a maximum width of 60 mm) and light platforms (with a charge of 50 to 100 kg and having a maximum width of 35 cm), one-quarter of the quantity of dust being distributed on the light platforms at the beginning and end of the barrier zone, one-half at each end.

b) Type 2 resembles the Polish type; it is distinguished by higher platform supports than type 1 and is also made up of heavy and light platforms (one-quarter of the dust being on the light platforms); the maximum load on the heavy platforms is lower than in type 1, since the width of the platforms must not exceed 50 cm, the charge being fixed at 60 to 70 kg of dust per metre of length of the platform. Light platforms of this type, like those in type 1, can be 35 cm in width and can carry a load of 30 to 35 kg/m.

The instructions mentioned contain many other details regarding the construction of platforms based on the experience gained during the trials. Particular emphasis was placed on having as rigid a design as possible for the platform supports, experience having shown that the effectiveness of the barrier is very considerably reduced if the supports can oscillate. According to the instructions in force platform supports and the attachments holding them to the rock or the roadway supports must be sufficiently rigid to ensure that "a force of 54 kgp acting on the platform supports at the level of the uprights and along the axis of the roadway cause a minimum displacement of 1 cm."

Numerous tests carried out in recent years were devoted to experiments with special designs using different type of platform, trough and bag which are employed as envisaged in proposals or patented techniques from Germany and abroad (25). For certain of these types, the tripping of the barrier is performed by a special mechanical device. Overall these trials did not give sufficiently good results to justify the use of such designs, which are slightly more complicated and are also dearer. It was found that the danger of non-functioning of the barrier increases with the complication of the barrier design. This is true in particular of the tripping devices which can in certain circumstances be displaced by movements of the rock or of the roadway supports, or can be affected by climatic influences (rust), so much so that it may even happen that the barriers can no longer be relied on to operate at the decisive moment if they have been in place for some time.

2.2126. <u>Making allowance for technical requirements</u>

Stone-dust barriers must be arranged in such a way that they receive the full force of the shock wave of an explosion and can react to it without any hindrance. Moreover, it is inevitable that allowance must be made for the winning equipment etc., when the barriers are being set up. Many trials have been carried out in respect of the problem posed by the arrangement of compressed-air lines, water pipes and electric cables, ducting, trolley wires etc. without hindering the effectiveness of the barriers. Mining regulations in force up to the present have contained certain indications regarding the installation of stone-dust barriers in roadways where the free cross-section is reduced by the equipment installed there (17). The regulation envisaged that "barriers must be arranged in such a way that their operation cannot be hindered by other equipment, ducting, etc.". The new inspection regulations provide that "the air doors and other fittings in the roadway, e.g. suspended conveyors, ducting, pipes etc., must not hinder the operation of the stone-dust barriers" (40).

In particular, it is important that in the event of an explosion the cloud formed by the stone-dust discharged from the barrier should not allow any passage of the flame. Consequently, the nex regulations require that the charge of stone-dust on each platform should cover at least two-thirds of the widest section of the roadway, almost symmetrically with respect to the axis of the roadway.

2.2127. The effect of other factors on the effectiveness of stone-dust barriers

2.21271. Properties of the stone-dust

Within the framework of efforts made over many years to develop fully the protection against explosions by means of stone-dust barriers, it was also possible to define the requirements to be met by the stone-dust in order to perform its task as well as possible without raising a health risk for the workers. Four conditions were precisely defined in the "Dortmund Chief Mines Inspectorate measures in respect of the inspection of stone-dust to determine its quality for use in stone-dust barriers" (18). Among the detailed provisions, we shall simply refer here to the fact that the stone-dust must be of very fine grain, in order to have the maximum possible extinction effect on an explosion, and that it must be capable of completely free movement at any time. One considerable disadvantage of the stone-dust barrier technique is that the dust may become caked relatively quickly in large workings where the air is very moist, so that the dust can no longer run freely. It is true that special chemical treatment can make the dust strongly hydrophobic; however, this treatment considerably raises the cost of the process. Up to the present, the replacement of the stone-dust by other hydrophobic materials has not progressed beyond the stage of a few limited trials. Another requirement to be met by the stone-dust is that it must not contain more than 3 % by weight of inflammable matter. This is the reason for the great precautions necessary in practice to ensure that the dust placed on the platforms is not excessively polluted by deposits of coal-dust. It is also important to guarantee that the stone-dust has no effect on the health of the workers. Consequently, it must have a very low content of elements which contain silicic acid and must not contain appreciable quantities of corrosive substances.

2.21272. Importance of the climatic conditions

We have already pointed out in the preceding chapter that high humidity of the ventilation air may considerably reduce the effectiveness of the stone-dust. On the other hand, the deposited coal-dust is moistened by the ventilation air, so that it becomes less free-running and thus reduces the risk of explosion. But of course the coal-dust becomes safe in the event of an explosion only if it has a very high moisture content. It may even happen that an explosion in a roadway is only somewhat weakened by moist coal-dust and may even become more dangerous when advancing with reduced force than if it had sufficient force to trip the nearest stone-dust barrier with fully effect.

The relative humidity of the ventilation air generally varies between 50 and 90 %. The trials carried out have not yet made it possible to establish whether the moisture content can have an appreciable influence on the course of a coal-dust explosion and on the extinction effect of a cloud of stone-dust. The temperature variations observed in collieries certainly have no effect in this respect.

In the majority of cases, the explosion tests were carried out up to the present with ventilation stopped, particularly when firedamp was used to provide the initial ignition. In point of fact, if it had not been done there was a risk that the tests would be abortive, because the firedamp would have been cleared away prematurely by the ventilation current. The question therefore arose of determining whether tests carried out with ventilation in operation would give different results. However, simple reference tests were made and no appreciable effect due to the ventilation was observed. It will also be clear that, in an explosion which is being propagated at a velocity lying between 100 and 1,000 metres per second, the fact that the mass of the air in the underground workings may or may not have moved by a few metres during that short period is hardly likely to be of importance.

2.21273. The effect of stone-dusting on top of deposited coal-dust

In addition of being used in stone-dust barriers, stone-dust is also used in large quantities for dusting deposited coal-dust. It is well known that this technique does not give particularly good results. Experience has shown that several layers of stone-dust cannot stop well-dried coal-dust from contributing to the propagation of an explosion. It is for this reason that the permissible content of non-combustible elements in the quantity of dust deposited has been changed by the new Dortmund Chief Mines Inspectorate instructions from 50 % to 20 %. In gateroads, the use of techniques which produce agglomerations of the coal-dust by means of hygroscopic salts is obligatory (36). There is no doubt at all that these measures at least produce a damping of the explosion and prevent coal-dust explosions from becoming too intense to be extinguished by anti-explosion barriers (see 2.2122). This is the way in which stone-dusting is used to strengthen the effectiveness of stone-dust barriers.

Stone-dusting on top of coal-dust may even have a negative effect, when it weakens a coal-dust explosion to the point where it no longer upsets a stone-dust barrier with sufficient force, but rather passes through the barrier zone at low pressure. Previous observations had indicated the possibility that this phenomenon might occur (24, 25). Precise observations of this subject have not yet been possible in the explosion trials carried out hitherto.

Other information obtained in the meantime has shown that it is not impossible that stone-dusting may have this disadvantage on occasions.

A proof of this is the fact that, if during explosion trials, a mixture of stone-dust and coal-dust is scattered in the zone lying between the ignition point and the barrier, the coal-dust explosion develops only weakly and, sometimes, is not even strong enough to bring the barrier into full operation, but only ignites the coal-dust after the barrier zone has been passed. The risk that an explosion may thus pass the barrier zone could arise primarily when stone-dusting has been badly and inadequately carried out, so that the explosion, as it passes through the inadequately stone-dusted area, again comes into contact over the whole of this part of its path with a certain quantity of coal-dust. Perfect neutralisation obtained by the use of stone-dust or hygroscopic salts would in general be considered a good complementary measure against explosions, while it would be a very valuable accessory measure when combined with the use of stone-dust barriers. The probability that stone-dusting on top of the coal-dust would prevent an explosion from becoming excessively intense, and therefore that the stone-dusting technique could ensure the effective operation of the barrier,is certainly much greater than the possibility of the neutralised coal-dust causing a reduction in the pressure of the explosion such that the pressure lies inside the dangerous limit zone or that the explosion can still be propagated, but be no longer capable of tipping over the barrier with sufficient force.

2.21274. Variations in the quantity of stone-dust

During the tests carried out in the last ten or twenty years, it has been observed that, in order to stop coal-dust explosions which have reached their full intensity, it is necessary in general to use 400 kg of stone-dust per m^2 of roadway cross-section (25). This result was also confirmed by subsequent experiments carried out up to the present day. Trials with weak explosions in their initial phase have however also shown that, in particular, the "very light single-plank platforms" of the Dortmund type, charged with only 100 kg per platform, reacted particularly well to weak explosions and were frequently able to stop such explosions even with a stone-dust charge of 80 to 100 kg/m^2 (25).

Consequently, earlier mining regulations required the installation of secondary barriers with a charge of 100 kg/m^2 in roadways linking two winning workings in one panel, at points where a main barrier could frequently not be installed because there was insufficient room and at places where the barrier would have to be moved frequently. More recent experiments have however shown that the utilisation of only 100 kg/m^2 does not provide sufficient control of the explosions, in particular when they reach a relatively high intensity in the initial phase. This is why the Inspectorate regulations in force (36) require every stone-dust barrier to have a charge of 400 kg/m^2 of roadway cross-section.

The recent experiments have shown that those explosions which are characterised by very high pressures and very high speeds of propagation of the flame can traverse zones protected by barriers with a charge of 400 kg/m^2 (see 2.21223). It would be interesting to investigate whether in such an extreme case the results could not be improved by the use of an even larger quantity of stone-dust. However, such experiments have not yet been possible.

2.2128. <u>The limits of the effectiveness of stone-dust barriers (summary)</u>

A brief examination of the results of the research carried out to date in the Federal Republic of Germany leads to the following conclusions:

The Inspectorate directives regarding the arrangement and design of stone-dust barriers take into account all the information gained regarding the course of methane explosions and coal-dust explosions, and developments in measures against these phenomena. The stone-dust barriers built according to these instructions and correctly sited in the underground workings, again provided that they are charged with a sufficient quantity of stone-dust, can be relied upon to stop coal-dust explosions by stopping the propagation of the ignition of the dust suspended in the air.

In the event of methane explosions proper, the stone-dust barriers can of course not completely prevent the combustion of the gas which is present; however, when the barriers are situated outside the gas accumulation zone, the mechanical resistance of the cloud of stone-dust reduces the range of the flame so that the barriers may be able to stop the ignition being transmitted to the coal-dust.

Provided that full attention is paid to ensuring that the stone-dust - which may have lost its free-running properties because of the humidity or which may have been heavily polluted by the coal-dust - is replaced by fresh dust and that free discharge of the barriers is not hindered by any equipment installed in the roadways, the effectiveness of a dust barrier is maintained in practice for an unlimited period.

When the coal-dust explosions are very weak and do not generate the air pressure necessary to cause sufficient dispersion of the stone-dust on the barrier in the cross-section of the roadway before the explosion flame reaches the barrier zone, the barrier cannot operate. This is particularly what may happen in the initial phase of an explosion.

In the limit zone of very intense coal-dust explosions, with very high propagation speeds, which may develop where there is an intense initial ignition or where the explosion is propagated over long distances in dust-laden galleries, it may happen that the stone-dust barriers do not fulfil their task. According to the information obtained hitherto, the time interval between the shock wave of the explosion and the point of the flame which is following it is too short for the stone-dust from the barrier to be dispersed across the roadway in good time.

2.22. Present programme of trials on stone-dust barriers

Other investigations of the effectiveness of stone-dust barriers are not included in the present programme of urgent work being done by the experimental mine, except for comparative trials - within the framework of very detailed experiments with water barriers - carried out occasionally with stone-dust barriers.

In this same work, trials are under way with the intention of continuing at the Tremonia experimental pit, as well as at other collieries, the investigation of very weak explosions in roadways of different cross-sections. Moreover, the present programme of work includes trials with explosions having long ignition paths, the special preparations for which are made at Tremonia and at another Dortmund pit. The course of these explosions and the measures against them in special topographic conditions (curves, forks) are being investigated by means of explosion trials in a pit at Essen.

2.23. Proposals for the continuance of research work with a view to obtaining all necessary information regarding stone-dust barriers

Bearing in mind present knowledge, the German research work into anti-explosion measures will probably be oriented for some time yet towards water barriers. The question of reliable effectiveness limits, of the best possible design and of the most suitable arrangement of these barriers in underground workings will require a large programme of work. Comparative trials with stone-dust barriers will always be necessary. The dust barriers are listed only in the annex to the programme and it is therefore unnecessary to deal in detail with the future research work here; this will be examined in detail in chapter 2.34 devoted to water barriers, and analogies can be drawn with respect to stone-dust barriers.

2.3. Water barriers

2.31. Introduction

Water barriers are older than stone-dust barriers. Since 1910 research work has been concentrated on the utilisation of water containers as protective arrangements against explosions and their application in German and foreign pits is known (33).

In the twenties, inspection and maintenance of the wooden and steel containers raised considerable difficulties, and for this reason stone-dust barriers have been exclusively used in Germany and in other countries.

The experimental mine at Gelsenkirchen, and later the mine at Dortmund, carried out some time ago trials with water barriers and reached some very favourable conclusions (4, 25, 33). But until recently, water barriers have been used only in isolated cases by reason of the technical difficulties, and because of certain objections of principle. It was only when the limits of the effectiveness of stone-dust barriers were clearly established in a precise manner by the trials, and also as a result of certain explosions, that the question of determining whether water barriers were not in fact capable of offering a better protection against explosions became topical again. The idea of carrying out new detailed investigations into this subject was encouraged by the fact that almost all the colliery roadways had in the meantime been fitted out with water pipes and that modern plastics are very suitable for making the containers. About 3 1/2 years ago the Tremonia experimental mine began new series of tests into the use of water barriers, testing a very varied range of technical conditions and types of application.

In the meantime, many coal-mines in the Federal Republic of Germany had replaced stone-dust barriers with water barriers, with the permission of the Mines Inspectorate. The new Inspectorate regulations (36) provide for the use of water barriers or stone-dust barriers for protection against explosions. Up to the present, no decisions for approval for general use of water barriers containing detailed provisions regarding design have been issued.

2.32. Present state of research

2.321. Effectiveness of water barriers against firedamp explosions

Explosion trials carried out with firedamp and without coal-dust have shown that, like the stone-dust barriers, the water barriers considerably reduce the range of the explosion flame by reason of the mechanical resistance of the extinction material used. In certain trials, the results obtained with the water barriers were better in that the propagation of the flame was stopped even more rapidly than in the case of stone-dust barriers (25, 33). But, on the whole, remarks made on the effectiveness of stone-dust barriers in the case of firedamp explosion proper (2.211) are equally applicable to water barriers.

2.322. Protection against coal-dust explosions by the use of water barriers

2.3221. Fundamental data regarding the effectiveness and optimum design of water barriers

The first trials carried out more than fifty years ago with water containers as a means of protection against explosions (33) were based on the fact that the water, for physical reasons, was expected to be better for this purpose than stone-dust. In fact, water has a thermal capacity five times greater than that of limestone dust and can therefore absorb more of the heat of the explosion flame. In addition, part of the water becomes evaporated and, by reason of its high evaporation rate of 539 kcal/kg at 100°C, it absorbs additional quantities of energy, which weakens the flame to a corresponding extent. Moreover, the disadvantage of the stone-dust that it cakes in the presence of high humidity and loses its free-running properties is avoided with the use of water.

In the past it was feared that the water, being vaporised by the shock of the explosion, would remain suspended in a cloud for a very much shorter time than stone-dust and would fall to earth more quickly, losing all its effectiveness (4).

Many investigations showed that this fear was without foundation. The principle of the effectiveness of water barriers as a means of protection against explosions is no longer doubted at all.

The experimental mine has on several occasions proposed, particularly during the last three years, to investigate water barriers and to carry out at Tremonia and in several idle pits explosion trials in normal working conditions. The appreciably more expensive trials carried out in these other pits were subsidised by the High Authority of the European Community for Coal and Steel, and also to some extent by the North Rhine/Westphalia Authorities and by the Steinkohlenbergbauverein at Essen. All these trials confirm that the results obtained with water barriers containing 200 litres of water per m^2 of roadway cross-section were comparable with those obtained with stone-dust barriers with a charge of 400 kg/m^2. As the bulk density of the limestone dust is very little different from the density of water, this is a fundamental and essential advantage of water barriers with regard to their practical utilisation; they require only one-half of the extinction material required by stone-dust barriers and, consequently, occupy only half the space in the roadway. The trials carried out with water barriers which gave the results set out in the following chapters consistently made use of 200 litres of water per m^2 of cross-section.

In addition, the fundamental ideas listed in the chapter on "stone-dust barriers" (2.2121) hold good for water barriers in respect of their range of application, design and optimum situation in the underground workings.

2.3222. Varying effectiveness of water barriers as a function of the pressure and speed of propagation of the explosions

As for the investigation of the stone-dust barriers, only a few general results of the water barrier trials - with different explosion intensities and different speeds of propagation - will be mentioned here. Detailed information will be given in the subsequent chapters which successively deal with the other parameters in the trials.

Reference should be made to the definitions and general remarks regarding average-intensity, very weak and very strong explosions which occur in chapter 2.2122.

2.32221. Explosions of average intensity

During the trials with water barriers it was observed that, as for the stone-dust barriers, explosions of average pressure and speed of propagation create conditions which particularly favour the effectiveness of the barriers. The effectiveness of the water barriers with such explosions can be briefly described as follows: not only are the water barriers as effective as the stone-dust barriers, but in many cases they were more effective and more thorough in their action than the latter (25, 27, 28, 33, 37, 38, 39). The flame of the explosion was frequently extinguished by the water after it had covered a shorter distance than in the case of the stone-dust barrier, the extinction having frequently occurred only a few metres inside the barrier zone. Water barriers with a charge of 200 litres/m^2 of roadway cross-section can therefore be considered as having a very high degree of safety in the case of coal-dust explosions of average intensity.

2.32222. Very weak explosions

In the case of coal-dust explosions producing very low pressures, trials with water barriers produced the same problems as with stone-dust barriers. It fairly frequently occurred that the shock wave was not strong enough to cause good distribution of the extinguishing material across the roadway, so that the flame passed through the barrier zone and ignited the coal-dust beyond it. Comparative tests carried out in the same conditions with stone-dust barriers also gave inconclusive results.

In consequence, particularly intensive studies have been carried out recently in the critical field of weak explosions (29, 37, 38). During the trials, very weak explosions were obtained by choosing a short distance between the ignition point and the barrier, or by mixing or covering the scattered coal-dust with stone-dust.

In general terms, it was observed that the effectiveness of the water barriers, when used with weak explosions, clearly depends very much on the cross-section of the roadways in which the barriers are set up. This point will be discussed in greater detail in chapter 2.3224. Over the whole series, confirmation was obtained for the observation that the barrier can be ineffective when the pressure of the explosion is too weak to cause sufficient dispersion of the extinguishing material across the roadways. The investigation of water barriers from this viewpoint is continuing. But in general, water barriers were certainly not found to be less effective than stone-dust barriers within the range of weak explosions.

2.3223. Very heavy explosions

In the case of very heavy experimental explosions, the water barriers were on several occasions found to be superior to the stone-dust barriers, since with very high speeds of propagation of the flame the water barriers operated effectively, whereas the stone-dust barriers no longer had any effect in similar conditions (25, 27, 33, 38). While the limit of effectiveness of the stone-dust barriers seems to be at flame-propagation speeds of some 600 metres/second, in several cases the water barriers were still effective in dealing with explosions producing speeds of propagation of some 1000 metres/second. This value also apparently determines the limit of effectiveness of water barriers with a charge of 200 litres of water per m^2 of roadway cross-section. As it is difficult and expensive - and moreover highly dangerous - to produce explosions of this intensity for testing barriers, it has not been possible to carry out many trials of this kind.

2.3223. Minimum distance between water barriers and the possible point of ignition

With regard to the running-up distance which is necessary for a coal-dust explosion to cause a water barrier to operate with maximum reliability, the general observations made in the chapter on stone-dust barriers (2.2123) apply by analogy. During the many trials carried out, no difference was noted in this respect between water barriers and stone-dust barriers (28, 29, 37). It was very evident that the minimum distance between the barrier and the ignition point depends to a large extent on the force of the initial ignitions. Whereas in the case where the explosion was set off by a strong ignition of firedamp, a distance of less than 50 metres was frequently sufficient to produce a shock wave sufficiently strong to guarantee effective operation of the barrier, a distance of 70 or even 90 metres was insufficient when the explosion was set off by a weak deflagration of gas, apart from exceptional cases.

2.3224. The importance of local conditions

Reference has already been made to the marked influence exerted by the roadway cross-section on the effectiveness of barriers, when dealing with the stone-dust barriers (2.2124); this is what became particularly clear, although it is true exclusively in the case of very weak explosions, during the trials with water barriers. In the tests with explosions of average intensity, the effectiveness of the water barriers was the same in roadways of 8 to 10 m^2 cross-section and also - in the extreme cases - in roadways of 22 m^2 cross-section (25, 28, 38). But in the case of explosions producing very low pressures and very low propagation speeds, the water barriers frequently did not operate in roadways 12.5 m^2 in cross-section, whereas at the Tremonia mine they completely fulfilled their task in a roadway 8 to 10 m^2 in cross-section (29, 37). From these observations it is clear that the flame traversed the barrier zone in the centre of the roadway - in the case of the greater cross-section - at some 0.5 to 1.0 metres from the roadway floor.

Consequently, in the case of water barriers, great prudence is required in drawing from the experience gained in roadways of small cross-section conclusions applicable to larger-section roadways. In the event of poor distribution of the water where the shock wave is too weak, in a roadway of sufficiently large cross-section the explosion flame can fairly easily make its way through the barrier zone, to re-initiate the coal-dust explosion with greater force on the other side.

In the case of coal-dust explosions against water barriers, explosions which are propagated in sections of roadway characterised by marked variations in cross-section and with forks in the roadway, it was observed that, as was the case with the stone-dust barriers, the shock waves are propagated without attenuation along a rectilinear course from the explosion; the effects in the side roads were different. In certain tests, considerably pressures were observed in the branch roads even when they formed an angle of more than 90° with the line of direction of the explosion (37); in other cases, the explosions were propagated in such branch roads with considerably reduced pressure, so that it was not sufficient to cause a barrier to tip over. However, when a water barrier was located at 50 metres from the fork, the explosion could once again build up until it reached the barrier and cause full operation.

Tne Mines Inspectorate instruction already referred to, providing that anti-explosion barriers must be installed at a minimum of 50 metres and a maximum of 75 metres from forks and crossovers (36), holds good for both water barriers and stone-dust barriers.

2.3225. Various types of water barriers and their effectiveness

In the fundamental researches into water barriers, use has regularly been made of recent years of water containers in the form of rectangular open troughs containing 80 litres and measuring approximately 70 x 50 x 35 cm. One empty trough weighs some 2.5 kg. A trough of this size can be handled easily, allows of adequate concentration of water without excess in the barrier and can easily be installed in roadways of normal cross-section. In main roadways with larger cross-sections, water troughs with a maximum capacity of 100 litres are considered more suitable.

The examination of particularly weak explosions has recently shown that it is advisable not to arrange the 80-litre troughs - as used to be the case - so that their longitudinal axis is parallel to the axis of the roadway, but to set them across the roadway, so that they offer one long side to the force of any explosion which may occur. In the case of very weak explosions, this ensures that there is a greater likelihood that the air pressure will still be sufficient to upset the trough.

The first experiments led to the idea that the material of which the troughs were made should break as easily as possible, so that they should break up immediately under the effect of the explosion and discharge the water. A relatively fragile PVC material was therefore considered most suitable (39). But more recent trials have shown that the easy-breaking properties of the material are apparently not so critical a factor. In the event of an explosion of average intensity, all types of troughs are immediately broken up; when however a weak explosion affects a trough, it tips it over rather than destroying it, even if it is made of very fragile material; this was observed in the most recent experiments. Consequently, some stronger material will therefore probably be equally suitable for constructing water barriers. The use of stronger materials will have the practical advantage of making damage during transport less likely.

In addition, there is far from being sufficient understanding of the problem of how a trough behaves under the effect of a very weak explosion shock, but it is a question of considerable interest because special attention must be paid to the limit value of explosions. The experimental mine is investigating this phenomenon at the surface in a shock-wave tube 50 cm in diameter, and the experimental roadway at Dortmund-Derne, authorised by the North Rhine/Westfalia authorities, is studying the behaviour of different water containers under different air pressures which are measured with great accuracy (20 to 300 p/cm^2), these air pressures being set up by weak firedamp explosions in a steel tube 2 m^2 in cross-section. The results of this research are not yet known.

A clearance of some 15 cm between the water containers and the roadway supports is considered advisable to ensure that their movement is not hindered, although good results were obtained in one trial where the troughs were placed directly under the roof-bars (27). As a precaution, a certain gap should however be left in view of the possibility that a very weak explosion which might tip the troughs over without causing them to break.

On the basis of the experience collected, water barriers are arranged in such a way that the various platforms, each carrying several troughs, are approximately 1.5 to 3 metres apart measured along the roadway axis. Actually the effectiveness of the barrier is not reduced when the series of platforms is interrupted at one point by a maximum interval of 10 metres, which is inevitable in certain circumstances. In this case, the quantity of water available should not be less than 50 litres/m^2 of roadway cross-section.

The long bars (platform supports) on which the troughs are supported should not be more than 40 cm apart. It is not necessary for them to be movable; they can be rigidly linked with the roadway supports by means of brackets, provided that the troughs can move freely by at least 15 cm with respect to the supports. It is very important to ensure that the platforms occupy at least two-third of the maximum width of the roadway in order to provide a guarantee that when the barrier is tipped over the water will be distributed over the whole roadway cross-section.

In several explosion trials, use was made of other types of water containers than troughs, namely small bags, bag-shaped rolls of plastic. The results were very satisfactory, but in order to assess the full value of this type of container, it would be necessary to test them under the effect of very weak explosions.

2.3226. Making allowance for technical requirements

The difficulties resulting from making due allowance for the equipment installed in roadways when setting up barriers without interfering with the anti-explosion protection and without infringing safety regulations have all already been discussed when dealing with stone-dust barriers (2.2126). The use of water barriers makes it possible to satisfy these two conditions slightly more easily. Frequently water containers can be installed more efficiently in the restricted cross-section of a roadway than can planks loaded with dust. For the water barriers, precisely as with the stone-dust barriers, it is important to ensure that all the extinction material is distributed as completely as possible in the roadway cavity when an explosion occurs; however, the experience gained indicates that this is no less likely if the water troughs allow certain gaps to occur in the roadway cross-section. The test results lead to the conclusion that the arrangement of the water troughs on a platform should ensure that there are no gaps wider than 1 metre.

Frequently, materials transported in the roadways are carried out by means of suspended transporters which require "free passage". To meet this situation, a certain number of trials were carried out with a major part of the water stored in small 30-litre troughs set along the axis of the roadway and touching one of the walls. In certain trials, all the water was placed in such troughs set all around the roadways. The results obtained hitherto are promising. However, other trials will be necessary, in view of the difficulty in providing effective protection against very weak explosions with special arrangements of this type.

The technical difficulties might perhaps be reduced, as a result of the trials which have sought to replace troughs set on platforms by a suitable type of suspension. In the shock-wave tube trials, and in certain underground explosion trials, the troughs were suspended from the four corners by plastic cord or fixed by means of twofolded-over edges slipped over bars. This method of fixing was satisfactory and will be tested in further experiments.

2.3227. The influence of other factors on the effectiveness of water barriers

2.32271. Importance of climatic conditions

Water barriers have the particular advantage of being less affected by the climatic conditions which obtain underground. The humidity of the ventilation air does not affect them at all; evaporation alone plays some part, especially in relatively dry and hot pits. There is certainly no difficulty, although there is a certain amount of labour, in filling the containers by means of a hose fitted to any one of the water taps available everywhere in the pit.

Moreover, the supervisory personnel must constantly check the water level. Special studies were therefore put in hand to find out how evaporation of the water could best be prevented. Covering the surface of the water in the open container with a thin film of oil or some other suitable chemical did not give good results, because the coal-dust is deposited on it and destroys the protective film. It would be desirable to use troughs closed by a lid or membrane of plastic material. Trials of such covers gave good results (28, 38), but the information obtained hitherto does not allow of drawing final conclusions.

The reader is asked to refer to the remarks on the influence of climatic conditions made when dealing with stone-dust barriers (2.21272).

2.32272. The effect of stone-dusting on top of deposited coal-dust

Reference has already been made (2.21273) to the various factors and general experience regarding the influence stone-dusting on top of the deposited coal-dust may have on the effectiveness of the barriers. These remarks hold good by analogy for the water barriers.

It remains simply to add that the use of hygroscopic salts ($CaCl_2$ or $MgCl_2$), in paste or powder form, is better in combination with water barriers than with stone-dust barriers. When spreading this powder or paste it is difficult to avoid some of this material falling on the dust platforms, where it pollutes the surface of the stone-dust, which has settled down in place, and reduces its free-running properties. This disadvantage is not likely to occur with water barriers.

2.32273. Variations in the quantity of water

The basic observation - frequently confirmed - that water barriers with a charge of 200 litres of water per m^2 of roadway cross-section provide an optimum quantity stemmed from the fact that, in previous trials, a quantity of 100 litres per m^2 was found to be sufficient, in several cases, to restrain the explosions and that 200 litres per m^2 gave better results than stone-dust barriers with a charge of 400 kg per m^2. In addition, a further increase in the quantity offered no extra advantage; in fact, during a series of tests where the water barriers with a load of 200 litres per m^2 did not operate because the shock wave produced by the very weak explosion was too weak, it was found impossible to obtain better results by using a charge of 400 litres/m^2, all other factors remaining unchanged (29). It has not been possible to investigate hitherto whether - in the case of extremely intense explosions, when the 200 litres/m^2 barriers remain ineffective - a larger quantity of water would extinguish the flame.

2.3228. Limits of effectiveness of water barriers (as against stone-dust barriers) (Summary)

To supplement the brief remarks on the effectiveness of stone-dust barriers (2.2128) and for the sake of comparison, we give the following assessment of water barriers on the basis of information collected hitherto:

In the "normal version" using troughs with a charge of 80 litres and 200 litres of water per m^2 of roadway cross-section, water barriers are undoubtedly as reliable as stone-dust barriers; in several trials they were even found to be superior to stone-dust barriers. When, in exceptional experimental conditions, the water barriers did not function, stone-dust barriers were also ineffective.

In the case of firedamp explosions proper, without coal-dust being involved, the water barriers can no more prevent the complete combustion of the gas present than can stone-dust barriers. As far as the reduction of the range of the flames - due to the mechanical resistance of the extinction material distributed - is concerned, water barriers have in many trials even been found to be somewhat superior; in no case were they less effective.

In the case of coal-dust explosions in the initial phase or very strongly attenuated, it may happen - with water barriers as with stone-dust barriers - that the shock wave of the explosion is not sufficiently strong to cause the production in the roadway of a sufficiently dense cloud of extinction material. It has not yet been proved sufficiently reliably that there is a difference of degree between the two types of barrier in this respect. Up to the present nothing gives any reason to suppose that the stone-dust barriers could still be effective where water barriers no longer operate effectively. In the case of explosions involving very high pressures and very high speeds of propagation, the two types of barriers tend to become ineffective. However, one series of trials did show that the water barriers are slightly superior in this respect to stone-dust barriers, since on several occasions they were able to stop explosions with propagation speeds of approximately 1000 metres/second, when the dust barriers had no effect at all.

The economic advantages of water barriers, and the fact that they are simple to handle, install and move, the small amount of maintenance work required and the ease of inspection are all advantages from the safety point of view; in fact, the difficulties arising from the arrangement of the site, from faults in design or from inefficient inspection can be avoided or eliminated more easily in the case of water barriers, so that there is a guarantee of more reliable protection against explosions.

2.33. Present programme of trials of water barriers

At present efforts are being concentrated on new trials of water barriers under the effect of very weak coal-dust explosions. To this end, research being carried out on the surface on the behaviour of water troughs under the effect of very weak explosions is being continued both in the experimental roadway of the Bergbau-Berufsgenossenschaft as well as at the Tremonia experimental pit (cf 2.3225).

In addition, other trials are under way in a pit at Essen; the purpose of these trials is to investigate the behaviour of coal-dust explosions when they run along curves and side roads, and to deduce the effect they have on water barriers.

Efforts have been made in this connection to clarify the important technical problem as to how far water barriers which provide "free passage" for the transport of materials i.e. a barrier where the water troughs are set symmetrically in the roadway cross-section, can be accepted without reducing effective protection against explosions. The tests also continued to cover suspensions for troughs in place of arrangements on platforms.

Finally, preparatory work is in hand with a view to continuing the investigation of particularly heavy coal-dust explosions characterised by a long "run-up" distance.

2.34. Proposals for the continuance of research work with a view to obtaining all necessary information regarding water barriers

The preceding remarks have already given some clear indication of the gaps which exist in present knowledge regarding the best possible protection against explosions, gaps which cannot be filled except by means of new research work, the programme for which is set out in the systematic summary which follows:

1) Very weak coal-dust explosions (with an effective static pressure of 1 kgp/cm^2 maximum and a short distance between the ignition point and the barrier),

2) Coal-dust explosions of average intensity (with an effective pressure of approximately 1.5 and 3 kgp/cm^2),

3) Very heavy coal-dust explosions (with effective pressures of more than 3 kgp/cm^2 and a particularly long "run-up" distance),

4) Weak and moderate coal-dust explosions which, along the path they follow, encounter considerable variations in roadway cross-section, curves, cross-overs and side roads.

To carry out these four principal groups of trials, it would be desirable to vary the following parameters:

a) the roadway cross-section (between 8 and some 18 cm^2) to the extent that suitable underground workings are available,

b) the quantity of water (between 200 and 400 litres/m^2 of roadway cross-section, especially in the case of very heavy explosions),

c) the arrangement of large and small water containers across the roadway cross-section and along the roadway axis, taking into account the clearance necessary for working operations,

d) the method of arrangement or suspension of the water containers,

e) measures to counteract evaporation of the water,

f) the quantity of coal-dust in the explosion roadway (between 300 and 900 grams/m^3 of roadway),

g) the relative humidity (comparative trials with very dry and more or less humid workings, to the extent that local conditions allow).

Special attention should be paid to groups 1 and 3, which still give rise to particularly difficult safety problems, and to the parameters a and c which are of particular importance for safety as well as for practical working operations. It would also be desirable to change the kind of coal-dust used for the explosion trials, although this could be put off for the time being.

Comparative trials with stone-dust barriers in all these series of tests would make it possible to study more precisely than hitherto the differences in the applicability and effectiveness of the different types of barriers.

To the field of weak explosions, it would be advisable to investigate carefully the relationship between stone-dusting on top of the deposited coal-dust or the use of hygroscopic salts and the effectiveness of the barriers.

In explosion trials with a long "run-up" distance, it is particularly important to know if the time interval between the shock wave and the tip of the flame becomes smaller as a function of the distance covered by the explosion in the roadway (and of its intensity?), or whether the speed of the shock wave and of the flame becomes constant - from which one might also deduce a constant time interval between the two phenomena.

Finally, an important purpose of the research would consist of investigating the possibilities of extinguishing firedamp explosions at the earliest possible moment and, in consequence, preventing them from transmitting the explosion to the coal-dust.

2.4. Rapid barriers (stone-dust or water)

2.41. Provisional results of research

To round off the report of the research carried out in the Federal Republic of Germany into anti-explosion barriers, it is necessary to deal briefly with the "rapid barriers", which are used predominantly during operations destined to isolate mine fires where there is a danger of an explosion, or in headings in stone as a protective measure against explosions which may be set off by shotfiring. These "rapid barriers" are thin superimposed wooden planks arranged in a wooden frame and loaded with stone-dust; they protect almost the entire roadway cross-section. More recently, such barriers have been made up of superimposed 30-litres plastic troughs set in a metal frame or suspended from chains.

Such devices have given good results during explosion trials both in the form of stone-dust barriers (25) and of modern water barriers which can be transported, installed and filled easily and rapidly. Several tests were carried out in collaboration with the Mines Rescue Station at Essen, during which rapid barriers of this kind comprising 30-litres troughs were set perpendicular to the axis of the roadway on superimposed planks; these barriers stopped coal-dust explosions set off by firedamp explosions at distances respectively 20, 30 and 40 metres from the ignition point (28, 38). The total quantity of water used was 50 litres/m^2 of roadway cross-section. Equally favourable results were obtained during trials where the same troughs were suspended from chains, 36 metres from the ignition point (29).

2.42. Further programme of trials of rapid barriers

The operation of isolating a fire is almost always associated with a certain risk of explosion, and it therefore seems valuable to continue the researches into the effectiveness of rapid water barriers which can be easily transported, and to seek to choose the best method of suspension.

Up to the present, rapid barriers have only been tested with explosions having a relatively short "run-up" distance.

Since the operation of isolating a fire is frequently carried out at a considerable distance from the seat of the fire, it is to be expected that the rapid barriers are equally likely to be affected by explosions which have already covered a considerable distance in the roadway. It is therefore intended to test rapid water barriers in such conditions as well.

3. Anti-explosion barriers in East Germany, Austria and Czechoslovakia

A report on anti-explosion barriers in East Germany, in Austria and in Czechoslovakia can easily be summarised by reason of the fact that research into the utilisation of such barriers in these three countries goes back to the same source. In 1910, Padour, an Austrian, proposed the use of water containers to stop explosions; his proposal envisaged flat metal receptacles of 18 litres capacity. In 1913, two other Austrians, Czaplinski and Jicinsky obtained good results with water barriers during trials at Rossitz (Moravia) (33). Following a serious explosion which occurred in the lignite mines in Bohemia, Mayer (14) carried out intensive researches in a drift near Brüx and observed that water barriers consisting of wooden troughs were superior to stone-dust barriers. On this basis, water barriers were prescribed by the Austrian Mines Inspectorate and proved their complete effectiveness during an explosion which occurred in 1959 in the Fohnsdorf mine (Styria) (19). A quantity of water of 200 litres per m^2 of roadway cross-section was provided for the isolation of the districts, and the isolation of each of the separate workings was provided by barriers with a 100 litres/m^2 of cross-section. Hanel (of the experimental roadway at Freiberg), starting from the trials at Brüx, observed in experiments with water and stone-dust barriers that the two types of barriers were equally effective (23). In the little experimental roadway, the trials used only 60 litres of water or 60 kg of stone-dust per m^2 of cross-section. Thus the experience obtained in the Austrian trials were also put to good use by the East German pits.

The regions of Austria mentioned are today part of Czechoslovakia. Water barriers have been maintained in use there, with a charge of 200 litres of water per m^2, this provision being still in force.

The East German pits (Soviet zone) have also continued the use of stone-dust barriers and water-trough barriers. The present regulation (30) contains precise provisions regarding the arrangement and construction of these barriers. The dust platforms have a maximum width of 60 cm, and exist in two types which are very like those used in Western Germany. Wooden or plastic water-troughs are used in six different sizes and contain from 25 to 130 litres of water. As a protection against evaporation, silicone oil must be used. The suspension devices which allow of a swinging movement of the platforms are forbidden by regulations. The other instructions agree largely with the Dortmund Chief Mines Inspectorate instruction.

The experimental mine at Dortmund has a copy of a report of the Ostrava-Radvanice Mining Research Institute which mentions an explosion which occurred in 1963 when a fire was being sealed off in the Marshal Koniev pit (in Northern Bohemia) fitted with water barriers (41). In 1964, coal-dust in suspension in the air exploded at the Kolumbus mine. Detailed information regarding the two accidents and the effectiveness of the water barriers are expected.

4. Research into anti-explosion barriers in the United States of America

The United States Bureau of Mines has carried out very large research projects on stone-dust barriers during the last ten or twenty years (5-11, 24, 25).

Between 1912 and 1918, Rice investigated experimentally stone-dust barriers of the Taffanel type at the Bruceton experimental pit, near Pittsburgh, in an explosion gallery 395 metres long and 5.4 m^2 in cross-sectional areas. The platforms consisted of planks 1.6 metres long and 0.35 metres wide bolted to the roadway walls. The barriers did not always have the desired effect, and this was probably due in particular to the rigid method of fixing the planks to the supports (24). Faulty operation was observed in particular when the explosion pressure was less than an effective value of 0.7 kg/cm^2. Subsequently, in about 1932, the same research institute developed a barrier consisting of planks some 50 cm wide simply resting on a beam (this was known as the "tipping platform"); each platform was loaded with a charge of 109 kg of stone-dust. During tests with this type of barrier it was observed that it was not sufficiently "sensitive" and that where weak explosions occurred, the dust was not adequately distributed.

Other research was directed towards experiments with "suspended platforms". These platforms were hung from the roadway crown by means of metal bars fitted with rings, so that the platforms could oscillate freely. When the swinging movement was sufficiently strong, the platforms became detached from the suspension. In addition, various types of box-design barriers were tested; these are wooden boxes of which the bottom is kept in place by a system of bolts which open under the effect of a shock wave. These boxes were 2.25 x 0.6 x 0.25 m and had a capacity of approximately 350 kg of stone-dust. In general terms, these types of barriers were not very effective and were not used for very long.

A number of trials spread over several years were devoted to the study of V-trough barriers. These comprised triangular-section wooden containers, laid in notches made in the wooden supports; these barriers were tipped over even by the effect of a weak explosion, thus discharging their contents.

Very good results were obtained with several variants of this type of barrier.

In the course of the last ten years, suggestions have been made in the U.S.A. to use bags of stone-dust as anti-explosion protection, so as to save the expense of complicated barriers. The stone-dust is stored in paper bags, then put into plastic bags and hung from cords under the roadway crown. Trials with these "bag barriers" did not however get the results expected (16, 21, 22, 25).

In 1919 the Bureau of Mines tested water barriers, which gave generally satisfactory results. However, as in other countries, the use of such barriers was abandoned in practice because it was thought that it would be too difficult to keep the water containers in good condition underground.

According to the information available, there is at present no interest in new investigations or in the use of anti-explosion barriers in pits in the United States, because the use of stone-dust or water barriers is not thought to be advisable, bearing in mind the normal method of working there, which gives rise to a very much branched system of roadways. In principle, stone-dusting is carried out as a protection against the propagation of possible explosion.

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Explosion barriers

Bibliographical survey of French tests

and

methods of combatting explosions near the coalface

This paper has been written at the request of the Working Party on "Inflammable Dusts" which reports to the Permanent Commission for Safety in Coal Mines. The object is to draw conclusions from certain test results on explosion barriers. By "explosion barriers" we mean any physical means of combatting explosions of coal-dust.

CERCHAR has been asked to prepare a memorandum on:

- French tests with stone-dust and water barriers,
- methods of combatting accidental explosions near the face: bags containing water or stone-dust dispersed by explosive or other means; water-atomizing devices; activated (triggered) barriers.

I. FRENCH TESTS ON STONE-DUST AND WATER BARRIERS

Taffanel's tests at Liévin and Commentry primarily highlighted the factors involved in the spread of dust explosions: volatile matter content, concentration of stone-dust, the size distribution of coal and rock characteristics of the source of ignition, the roughness of the roadway walls, the effect of reflected waves on the flame when the tests are carried out in an open roadway.

I.1. The Liévin tests (1909 - 1910)

The experimental roadway was 230 m long, with a cross-section of 2.8 square metres. The volatile content of the coal was 30 % (net basis) and the ash content varied between 6 and 12 %; different size consists of coal were used in order to vary the proneness to flame propagation.

Coal-dust placed in front of a mortar was whirled up and ignited by the firing of 240 grams of blasting gelatine.

The barriers were improved during the tests. Initially, the stone-dust formed a pile which obstructed 34 % of the section over a length of 10 metres. During the subsequent tests the stone-dust was placed on superimposed shelves, located along the roadway walls. In the final tests, the barriers were constructed of fixed shelves, set transversely in the roadway, and on which water troughs or stone-dust were placed.

The intensity of the explosion was varied by adjusting the fineness or density of the coal-dust deposit. This gave results showing flame velocities running from 20 to 860 m/sec. Various suppressants were tried out: flue ash, shale, sand, water; they were tried in different quantities.

The following conclusions can be drawn from these tests:

- it was possible to establish for the first time that barriers could suppress explosions in different conditions;
- the coal-dust explosions which are most difficult to suppress by barriers are of the pulsating type, i.e. the slowest explosions;
- since the shelves were fixed - a fact not conducive to effective dispersion of the stone-dust - the amounts of non-inflammable dust were very large. Yet even with an indifferent extinguishing agent, 70 litres of stone-dust per square metre of gallery were adequate to stop - at distances between 150 and 170 metres from their source - slow explosions whose flame speeds are between 20 and 40 m/sec. 270 litres per square metre of ash were enough for violent explosions, whose flame speeds reached approximately 500 m/sec. The amounts of stone-dust here are less than those required by the safety regulations of the various countries;
- the tests, taken as a whole, suggest that water is the suppressant to be preferred.

I.2. The Commentry tests (1912 - 1913)

The roadway was 1115 metres long; it was open at both ends and contained curves, angular turns and a sloping section. The cross-sectional area was between 3.5 and 8.7 square metres and the roadway was fully timbered.

The coal was identical with that used at Liévin.

The explosion source was in a 6-metre deep cross-drift, near the middle of the roadway. Whirling-up and ignition of the coal-dust was induced by the firing of 400 grams of black powder in a mortar and of 600 grams of naphtalite "rock and methane" explosive suspended above. The stone-dust barriers consisted of shelves resting on fixed supports. Each of the 15 shelves was 60 cm wide and 160 cm long, the gap between each shelf being 60 cm; each was loaded with 100 litres of ash. The water barriers consisted of two troughs each holding 650 litres of water, and this water was discharged over a period of several seconds, following on the passage of the pressure wave.

Such tests as were carried out at Commentry confirmed, in roads of large cross-section, the previous results with regard both to barriers in general and to water as a suppressant.

The main body of our knowledge of traditional barriers was gained as the results of the Taffanel test.

More specifically, they led to the achievement of the suppression of weak explosions, where the air current is not always able to disperse the suppressant effectively. Nevertheless, the Taffanel tests on neutralisation showed that it was capable - if properly carried out - of suppressing weak explosions even without recourse to barriers. A tenable conclusion is that stone-dusting and barriers provide jointly a satisfactory solution.

II. RELATED METHODS OF COMBATTING EXPLOSIONS

There is always every reason to suppress explosions as soon as possible. Tests on barriers throughout the world haven, in fact, shown that it could be very difficult indeed to halt explosions with flame speeds in excess of 800 m/sec.

Traditional methods used in development work - so many dust explosions did, in fact, start as a result of shotfiring in development workings - have been stone-dusting as close as possible to the faces and barriers placed at an optimum distance from the face.

Other methods of safeguarding development roadways can be envisaged. Since the initial explosion can be fairly weak and, consequently, the dispersion of the suppressant by the air current may be inadequate, studies have been made of various devices which might perhaps improve the protection of development roadways: these have included devices which would most effectively disperse the suppressant. Such dispersion may be carried out either, in a systematic way prior to shotfiring (shotfiring being one of the most prevalent causes of the initiation of coal-dust explosions), or by a device for detecting the explosion; the latter method having the advantage of giving protection against every known cause of explosion.

The following sections will review each of these two methods of protection in turn.

II.1. Methods applied systematically during shotfiring

These methods are used as close as possible to the shotfiring area, only a few metres away, so that the atomization of the suppressant will, if possible, prevent the ignition of the inflammable air-firedamp-dust mixtures which may exist or may arise during shotfiring near the face.

The following devices will be studied in turn:

- water bags or stone-dust bags dispersed by an explosive charge,
- water atomizing sprays set in operation before shotfiring takes place.

II.1.1. Water and stone-dust bags

F. Otasek was the first person to perfect a process for eliminating the danger of shotfiring with "rock" explosive in gassy and possibly dusty workings. The process consists of water stemming, coupled with water atomization obtained by exploding one or more plastic water bags, by means of an explosive charged ignited 0.5 to 1 sec. before shotfiring.

The tests were carried out in a roadway 2 metres in diameter. The shotholes were simulated by a mortar containing 500 grams of "rock" explosive. The barrier consisted of two bags, each of which contained 7 litres of water with an explosive charge, placed 1.50 metres in front of the mortar nozzle and 1 metre above its axis. The coal-dust was spread out in front of the mortar nozzle. Without water, the shotfiring always ignited the dust. In the presence of atomized water, the dust was either not completely ignited, or the resultant flame was significantly shorter. Similar tests were carried out on the prevention of firedamp explosions, which very often transmit the shock from the explosive, so causing a dust explosion.

As a result of this, similar tests were carried out by Soviet research workers at MAKNII. An attempt was made, in a roadway of 3.2 sq. metres cross-section, to suppress the ignition, either of a firedamp mixture, or of a coal-dust cloud, or of a mixture of air, firedamp and coal.

The tests differed from those of Otasek in that the water was dispersed by two electric detonators.

Prof. Cybulski must be credited with a large number of tests in very dissimilar conditions, but always in a gassy environment and without coal-dust.

- He used roadways with cross-sections from 2.9 to 11 sq. metres of varying shape.
- Ignition was caused either by electric detonators, or by different explosive charges in the mortars and angle-shot mortars placed in different locations in the gallery.
- His studies included the influence of the time-lag between the dispersion of the water or the limestone dust and the initiation of a firedamp explosion - 0 to 2,000 ms.
- In addition, he varied the character, location and quantity of the suppressant (30 to 120 litres of water; 7.5 to 120 kg of limestone dust).
- The water and dust bags were dispersed equally by detonators or explosives.

At the Freiberg research station the flame produced by a "rock" explosive in a mortar, with water bags dispersed by explosive, was photographed to try and assess the optimum location of the bags (1 metre) and the preferred time-lag between dispersion and shotfiring (23 ms).

The following conclusions can be drawn from the body of tests made at the different research establishments on bags of water and stone-dust:

The method can be recommended as a useful additional precaution in cases of instantaneous shotfiring or short-delay shotfiring, which supplements conventional methods of neutralisation and barriers, providing additional safety by preventing the occurrence of explosions in a large number of cases. Unfortunately, this method is liable to be vitiated in cases where there are recesses which cannot readily be reached by the suppressant - corners of rectangular roads, stable-holes, etc. or when the ignition of firedamp takes place sometime after shotfiring - ignition by a detonator or deflagration explosive, a cartridge smouldering under the spoil. The test results with the angle-shot mortar seem to indicate that the method is not always effective when the firedamp is likely to be ignited by a bared shot; this drawback is not serious because the method is scarcely applied with delay shot-firing.

From all these tests we can conclude that the most favourable conditions are these:

- bags placed between 1 and 3 metres from the face,
- time-lags between dispersion and firing of between 50 and 500 ms in the case of water bags, and between 50 and 1000 ms with limestone dust,
- the amounts of water required are between 3 and 13 litres per square metre of cross-section, depending on the conditions,
- the type of explosive in the bags has little effect on the result,
- safety is increased when the rock-breaking explosive is placed in a water sheath.

This method has already been used when shotfiring in rock with "rock" explosive in very gassy workings.

II.1.2. <u>Tests with water atomizers near the face</u>

The tests were intended to develop atomizers in order to suppress dust explosions starting in dead ends at the moment of firing. The atomizing sprays are started systematically several seconds before firing.

Three roadways were used: one, 144 metres in length and 2.5 sq. metres in cross-section; a second, 45 metres long and 10 sq. metres in cross-section; the third, at Tremonia, was 275 metres long and between 8 and 10 square metres in cross-section, where Dr. Meerbach's tests were carried out. The dust explosions were set off either by firedamp ignited by explosive - as a strong source - or black powder igniters - as a weak source - or by using explosive to ignite a previously-formed dust cloud. The dust deposit was made up of pure coal or partially stone-dusted coal - Montrambert coal at Verneuil, standard coal at Tremonia.

Tests in the 45-metre roadway assessed the effectiveness of atomizers against a roof layer of firedamp extending on both sides of the atomizer.

The tests used simple jets and different types of atomizer mostly directed towards the far end of the gallery. The distance between the atomizer and the face varied between 10 and 21 metres. Atomization was usually carried out 5 secs before firing, but in the case of the roof layer of firedamp the time-lag was increased to 30 secs.

The flow of water varied between 40 and 260 litres/min/sq. metre, a range within the compass of everyday mining conditions.

The tests showed that:

- the larger the cross-section, the larger becomes the amount of water required per square metre of cross-section to suppress a violent explosion. A quantity of 1200 litres/min was insufficient for a cross-section of 10 sq. metres - an amount which is already hard to provide in actual mining conditions. In such a cross-section, of flow of 500 to 600 litres/min is unable effectively to arrest explosions other than those set off by a weak source. Since these are unable to disperse a simple jet in a suitable way, the only devices which are relatively effective are those which produce a mist of small droplets.
- All other things being equal, explosions which were not arrested in the 45-letre roadway, were not arrested in the 275-metre roadway either.

This difference is due to the expansion waves being reflected on to the mouth of the short roadway, creating turbulence which favours the propagation of the explosion.

- In the case of roof layers of firedamp, atomization of water creates air currents which carry away and dilute the methane; the flame weakens or stops when it meets this diluted zone.

It is instructive to compare the methods with water bags and atomizing sprays: the atomizers have the advantage of acting for several seconds before and after firing, while the water from bags is effective only for about half a second on being dispersed from the bag.

On the other hand, while it is difficult to keep more than 10 litres of water suspended in the air at any given moment with atomizers, there is no reason why one should not have several dozen litres suspended with the water bag method.

II.2. Triggered barriers

An activated (triggered) barrier consists of two separate parts: a dispersing device and a detector-trigger device.

The ideal dispersing device should enable the suppressant material to be sprayed into the entire cross-section, and as uniformly as possible; dispersion must be rapid, so as to be completed before the arrival of the flame of a rapid explosion, and should last long enough to suppress the flame of a slow explosion.

The dispersion must be of a reproducible type.

The detector-trigger device consists of a detector sensitive to the pressure wave or to the flame of the explosion. Such a detector must be selective, so as not to react to a pressure wave due to firing or to stray radiation. The trigger receives the signal from the detector and activates the operation of the dispersing device.

French, British, Soviet and American tests will be reviewed in turn.

II.2.1. The Montluçon tests on triggered barriers

This study was carried out in a 150-metre roadway, 2.5 square metres in cross-section. The coal-dust used - dispersed at a rate of 500 grams per cubic metre - contained between 25 and 30 % volatile matter, and had a specific surface area of between 450 and 700 square metres per kilogram.

Six igniting sources of different strength set off the explosion: either a variable volume of a 9 % air-methane mixture ignited by 200 grams of black powder, or by fusion of an electric wire, or a dust cloud ignited directly by 1100 grams of black powder.

A first series of tests involved gases and vapours. The substances used were:

Phosphorus oxychloride	($POCl_3$)
Carbon tetrachloride	(CCl_4)
Carbon dioxide	(CO_2)
Sulphuryl chloride	($SOCl_2$)

The distance between the barriers and the source varied between 40 and 75 metres.

The dispersing device alone was studied and not the detector. The only tests to give favourable results were those using large quantities -

30,000 litres - of carbon dioxide gas, released in 3.5 secs from three cylinders equipped with rapid-release valves. The only explosions arrested were comparatively slow ones, with flame velocities of about 50 metres/sec. In addition, this type of barrier would not be very practicable in current mining use.

Later, tests with (stone)-dust barriers were carried out - using dusts of:

Sodium chloride
Cryolite
Clay -

the barriers being placed between 20 and 30 metres from the face. The tests led to the design of a trigger device which enabled violent explosions to be arrested in a large number of cases, where flame velocities reached several hundred metres per second.

The selected device was as follows: the detonators for dispersing the dust were incorporated into the secondary circuit of a 200-6 V transformer. The primary circuit, which comprised a tin foil placed 12 metres from the far end of the roadway, was fed by a 0.3 amp current. The air current from an explosion broke the tin foil, the primary current was suddenly broken, and the current induced in the secondary circuit set tripped the detonators.

Sodium chloride and cryolite seemed to be equally effective: in fairly small quantities - 2 kg per square metre - they were able to arrest violent explosions.

Unfortunately, the trigger device did not operate reliably at this stage. Development on it, halted in 1939, was only resumed after the Montluçon Research Station moved to Verneuil. It should be pointed out that dispersion by means of explosives can have certain dangers for the workmen in the event of ill-timed triggering.

Recent technical advances in electronics have opened up new prospects of developing a trigger device. Some months ago CERCHAR resumed work on a detector.

II.2.2. British tests on triggered barriers

In 1954 the Buxton Research Station became interested in different types of detectors. Among the flame detectors examined, studies were undertaken of fusible wires, inflammable materials, thermistors, air thermometers, and ionisation and radiation detectors. The best results were obtained with a fusible nylon thread and with an air thermometer with a reaction time of 15 ms. Laboratory tests were made on an air-velocity detector whose operative threshold was preset. Unfortunately, these tests did not yield practical results.

Some years later research work was resumed on triggered barriers, the emphasis this time being on the dispersion method.

Work was done on the type of conditions in which a dust explosion could be arrested 62 metres from the far end, using atomizers covering the entire cross-section of the roadway, or by means of a single water jet.

The roadway was 1.22 metres in diameter and 100 metres long. The finely-crushed coal contained 35 % volatile matter and was used in its pure form or blended with limestone dust. The ignition sources produced either a weak explosion - 30 metres/sec - or a violent explosion - 180 metres/sec. The factors studied were the design and location of the atomizers and jets, the requisite water flow, the necessary sprinkling time before the arrival of the flame at that point, and the violence of the explosion.

The water flow required was considerable: 500 litres/min or more - a very high figure in view of the small cross-section. In practice it would be very difficult to obtain the same amounts per square metre of cross-section in a large roadway.

The tests showed that to be effective, atomization need only precede the explosion by a few tenths of a second.

II.2.3. Soviet tests on triggered barriers

Maknii have developed a barrier controlled by a photoelectric cell. This cell, which is sensitive to infra-red rays, gives a signal which controls the firing of a detonator, releasing a spring which activates the troughs of a barrier. During the tests, the barrier was placed between 20 and 60 metres from the far end of the roadway. The cell was placed between 5 and 7 metres from the same end. The detonator was set off 2 or 3 ms after the flame passed the cell. The suppressant material was either inert dust, at a rate of 50 kilograms per square metre of cross-section, or water. Water proved to be less effective with slow explosions. It would appear that the optimum distance between the far end of the gallery and the first trough was between 20 and 25 metres.

By 1962 this type of barrier was already used in over 300 workings in the Donbass.

II.2.4. Triggered barriers in the U.S.

A triggered barrier, designed by Fleming and Thomson in 1949, has not, as far as we know, led to any test results being published.

The U.S. Bureau of Mines reported on the state of its researches on triggered barriers to the Sheffield Conference in 1965. The flame detector is a photovolt cell using treated silicon, giving a signal which, relayed via a detonator, releases carbon dioxide from a sealed container, thus discharging 23 kilograms of potassium oxalate powder into the atmosphere.

The tests showed that the device could arrest the ignition of 43 cubic metres of a 9 % air-methane mixture. Tests are planned for improving the barrier and testing its performance in a coal-dust environment.

CONCLUSIONS

Conventional water or inert dust barriers:

- These have been proven under mining conditions; they are simple, robust, typically "mining" solutions, relatively easy to maintain.

- They do not afford protection against the full range of accidental explosions, particularly very slow or rapid explosions; their deployment is not always easy.

- Their capacity for dispersing the suppressant material might well still be improved, as also the composition of the suppressant and our understanding of the best location.

Arresting methods close to the face:

- These guard against the ignition of dust and even methane, or arrest the propagation of such ignition at an early stage; they provide a satisfactory dispersion at the moment of maximum risk.

- They do not give protection in certain cases, especially if the explosion starts at a point other than at the face, or at a time other than when shotfiring. Unlike water atomizers, water or dust bags do not afford protection when the explosion is initiated a few moments after firing, as is the case, e.g. when a cartridge is burning under the excavated material. Their cost price is considerable and their operation somewhat cumbersome.

- They cannot replace the traditional barriers but should be used in conjunction with them, and - together with neutralisation - provide a considerable measure of additional safety.

Triggered barriers

- A sound type of triggered barrier should - at the right moment and for an adequate period - provide good dispersion, which should enable one to use small amounts of suppressant materials; one could then use combustion suppressants which will be more effective than water or limestone dust.

- The application of such barriers would be particularly valuable several dozen metres from the face, when the explosion has not developed sufficiently to disperse readily the material carried on a conventional barrier.

- It is however a solution which is not a "mining" solution, and which is expensive and complicated; it is not sufficiently tested as yet; the development of a selective detector, which would cut out ill-timed triggering, is not easy.

- Yet this is perhaps the means which we may hope will bring the greatest improvement of safety in the future.

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Stone-dust Barriers in Great Britain

Synopsis

A brief review is given of the developments and experiences leading up to the provision of stone-dust barriers in the mines in Great Britain. Some of the difficulties met with in the installation and maintenance of barriers in present-day mining practice are discussed, and modifications and alternatives to the present system of stone-dust barriers are described.

The need for further research and development, and the facilities now made available by the commissioning of the new large-scale coal-dust explosion gallery at the Buxton Station of S.M.R.E. are discussed.

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THE DEVELOPMENT OF STONE-DUST BARRIERS

Although the widespread introduction of stone-dust barriers into British mines is of comparatively recent date, the idea of using such devices to arrest a coal-dust explosion was under investigation in the early years of this century, first by Taffanel in France and later by Rice in America and Beyling in Germany. It was, of course, already well known that a progressive dust explosion could be prevented by strewing on the roof, sides and floor sufficient incombustible dust to render the cloud of mixed dust that could be raised in the air incapable of propagating an explosion, and the idea of a concentrated barrier of incombustible dust appeared attractive.

The considerable measure of success achieved in these early researches led to the introduction of barriers in a number of countries, and to further investigations which have continued to the present; much of the recent work has been carried out in Germany, by Schultze-Rhonhof, and in Poland, by Cybulski. A fascinating and detailed review of the researches up to 1952 has been published by Dr. H.F. Coward.

During the course of the early work on barriers a considerable insight into the principles of their operation was gained and a wide variety of types of barriers was tried before the designs now current were developed. Thus it was soon established that a barrier of dust on longitudinal shelves fixed to the roadway sides, though possibly the most convenient arrangement, was ineffective, and that transverse shelves must be used; and also that the use of fixed shelves to hold the dust was unsuccessful except in the case of a violent explosion. Shelves hung from the roof also proved of doubtful efficacy as they tended to swing in the blast rather than allow the dust to be rapidly dispersed.

These findings led to the examination of barriers constructed of units which could be so disturbed by the blast ahead of the explosion flame as to facilitate good dispersion of the dust they carried.

Dr. Coward's paper gives detailed descriptions of well over twenty different designs of self-operating barriers on which tests were made, including shelf, box and trough types, and certain so-called concentrated barriers. Of these, the ones found most generally successful and practicable were the German Dortmund barrier and the Polish improved barrier. Although both in Germany and in Poland it had been found that barriers of the American V-trough type, and in particular the modification with loose boards tried by Cybulski, were very promising, in practice the shelf types were preferred - possibly because of their simpler construction.

In the course of these researches a number of observations of general significance had been made. It was found that although explosions of moderate violence were readily arrested by barriers, very weak explosions were often difficult to stop, as were also extremely violent explosions. With very weak explosions the blast ahead of the flame either did not disturb the barrier sufficiently or did not cause the dust to be properly dispersed before the flame arrived. Very strong explosions, in which the flame had almost caught up the blast, again did not allow the dust to be sufficiently dispersed before the arrival of the flame.

The successful operation of a barrier was therefore a question of obtaining the correct relation between the sensitivity of the barrier and the characteristics of the explosion, and since these latter varied with the progress of the explosion the siting of a barrier in relation to the source of the explosion was important. Thus, although it was clearly desirable to stop an explosion as early as possible, barriers placed too near to the source of an explosion were frequently unsuccessful. To be sufficiently sensitive to blast the barrier units should be of light construction and of relatively small dust capacity. Schultze-Rhonhof suggested that barriers sited at some distance from the expected source of an explosion should contain some units or shelves more lightly loaded than the rest. Although it was expected that an explosion would usually have become violent by the time it reached the barrier, there could be occasions when it was still relatively weak, and the lightly-loaded shelves were intended to provide for such occasions. There was also general agreement that the units of a barrier should not be too close together and that they should be so arranged that the free flight of the boards should not be impeded. The importance is now recognised of adequate dispersal of the barrier material and of the production of a dense cloud of material capable of being well maintained in suspension.

Although research had been mainly concerned with self-operated barriers of stone-dust, tests had also been carried out with water barriers and with barriers remotely operated by the advancing explosion through the agency of some trigger device, and these will be mentioned later.

THE APPLICATION OF STONE-DUST BARRIERS

A widely different attitude was taken by the mining engineers of different countries to the use of stone-dust barriers. In the United States barriers were tried in many mines for a time but became largely abandoned, due partly to difficulties associated with rapid face advance, in favour of general stone-dusting. In France, Holland and Belgium, barriers, though not universally required by Regulation, became used as supplementary protection to general stone-dusting in certain places. In Poland more emphasis has been placed on the use of barriers and, in conjunction with a good level of general stone-dusting, they are regarded as a necessary safeguard. In Germany, although there was in the past a limited requirement for stone-dusting, much importance was placed on the provision of stone-dust barriers: recently, however, alternative safeguards have been receiving attention.

In general, presumably as a result of the more complicated ventilation systems of horizon mining, continental practice has been directed more to the use of barriers as a means of sealing off one district or circuit from another than to the siting of barriers in relation to potential sources of ignition.

In Great Britain the use of barriers did not find favour and it was believed that it was better to prevent the occurrence of a dust explosion by adequate general stone-dusting than to allow an explosion to develop until arrested by a barrier at some distance, by which time there could be loss of life both of men in the path of the explosion and of men downwind being overcome by the toxic afterdamp. This belief was no doubt reinforced by the evident beneficial effects of the introduction of general stone-dusting.

It was, nevertheless, early recognised that in practice it could be difficult to ensure that conditions were always and everywhere safe. Research has shown that fairly intimate mixing of the stone-dust with the coal-dust was important, and that a thin layer of coal-dust lying over even a thick layer of inert dust, or coal-dust-rich zones along a road, could still allow an explosion to propagate. The fact that explosions, though much limited in their extent, could still happen demonstrated the practical difficulties in achieving a sufficiently even degree of stone-dusting.

With the widespread introduction of belt conveyors the situation became still more unsatisfactory, and it was realised, and demonstrated by research, that coal-dust on the belt itself, and in spillage along the run of the conveyor, could not be effectively neutralised by general stone-dusting.

These deficiencies were tragically emphasised by the explosion at Easington Colliery, in May 1951, and the need for additional precautions was stressed in the Report of the Inquiry into the cause and circumstances of the disaster.

After discussing measures to minimise the hazard of coal-dust in mine roadways, the Commissioner, the then Chief Inspector of Mines, went on to say:

"When all these measures have been taken there will still remain the problem created by the ease with which coal-dust can be raised by the blast of an explosion from the conveyor structure and from the belts. The only practicable solution at present in sight seems to be the provision of some form of dust or water barrier at suitably chosen sites. There is still much to learn about barriers, but experience in Germany with dust barriers of the shelf type has been sufficiently favourable to justify their adoption in this country until something better is devised. Research should be carried out in the further use of dust barriers and in the development of water barriers, and in the meantime shelf type barriers should be installed on conveyor roads."

Before the actual publication of the Report of this Inquiry action had already been taken by Mr. H.E. Collins, then Divisional Production Director, and barriers of the German type were introduced in the Durham Division in January, 1952. This action was followed, in 1953, by the issue by the N.C.B. of a general directive on the provision of stone-dust barriers.

The system of protection required by the Directive, though based largely on German practice, differed from practice on the Continent in requiring barriers, with certain exceptions, only on roads in which gate conveyors were installed for transporting coal from the coal face, and special attention was paid in the siting of the barriers to transfer and loading points.

In October, 1960, Regulations came into force requiring stone-dust barriers of a type approved by the Minister to be provided in or near lengths of road on which coal, other than anthracite, is carried by means of a conveyor, and which are in an area throughout which the flame that may be caused by an ignition of inflammable gas or dust occurring at a working coal face or such other place as the mine manager may determine is likely to extend. Other than this the Regulations make no detailed requirements as to the siting of the barriers but require the Manager to prepare a suitable scheme in respect of each area concerned.

PRESENT PRACTICE IN GREAT BRITAIN

Following the introduction of these Regulations a Sub-committee of the Coal Industry National Consultative Council's Safety and Health Committee was set up to consider whether, in the light of more recent research and experience, the N.C.B. Instruction on the type and siting of barriers could be improved. The recommendations of the Safety and Health Committee were published by N.C.B. in the Report on Stone-Dust Barriers on Coal Conveyor Roads, of May 1961, and the more important changes proposed were as follows.

The Report, in view of the now-recognised need for precautions in wet and damp conditions, and of the possibility of ignitions of firedamp in naked-light mines, recommended that barriers should be provided even in wet conditions and in naked-light mines.

It was also recommended that, in future, barriers should be of the design developed and used in Poland. This was based on a careful consideration of the available information on the German and the Polish designs, from which it appeared that the Polish barrier had been more extensively tested and also was thought to be of a construction likely to be more effective in weak explosions.

On the siting of barriers, it was considered that the barriers should be sited in relation to possible points of origin of an ignition, and since in coal-producing districts more explosions occur at or near the coal face, barriers should generally be provided in relation to working coal faces and aimed at minimising the possible spread of an explosion. In order best to achieve these objectives it was evident that a system of two barriers was necessary, one barrier relatively near to the coal face and a second barrier a further distance away.

The first barrier should be installed within the range 50 - 120 yards from the nearest point of the face; if sited closer to the face the barrier is likely to be ineffective due to too short an interval between the flame and the blast ahead. It should be composed of slightly loaded shelves readily disturbed by weak blast.

Although a barrier of this type sited as above should succeed in arresting most explosions which might occur at the face, stone-dust barriers cannot be relied upon to arrest a firedamp explosion. It is therefore possible that if a large firedamp explosion occurred at the face, or if there were a firedamp layer at or near the site of the barrier, flame could be projected past the barrier and ignite coal-dust further outbye. This risk is guarded against by the second barrier.

The second (or heavy) barrier should be sited far enough from the coal face for there to be little risk that it may be reached by a firedamp explosion at the coal face, or a layer of firedamp at the roof over the first barrier, but not so far away that it cannot operate effectively. Little is in fact known of how barriers will operate at distances of more than about 400 yards from the source of an explosion, and it is recommended that the second barrier should be installed at a distance of 200 - 350 yards from the face. This barrier needs to carry more dust than the first barrier, as the explosion can have developed greater violence at the greater distance from its source: however, in some conditions the explosion may still be relatively weak and the design of the barrier must be such as to cover the two possibilities. It should therefore be composed of some lightly loaded shelves, similar to those of the first barrier, and some shelves more heavily loaded to ensure, by virtue of their greater stability, that if the interval between the blast and flame is relatively long, the dust will not all have reached the floor or become too widely dispersed before the flame arrives.

Although these light and heavy barriers will be the kinds needed in most places, in some circumstances, for example where the distance between the gates of adjacent newly developed faces is insufficient to allow the installation of both light and heavy barriers, there will be a need for a barrier intermediate in size and loading.

The above Report gives detailed recommendations based on this principle of protection by two barriers, designed to arrest an explosion near its source and to prevent it spreading to other districts. The recommendations deal with the siting of barriers in long-wall workings, headings and in bord and pillar districts. The types of barriers at present approved are detailed in the Regulations.

It should be emphasised that although these barriers may appear crude and simple devices, care must in fact be taken to ensure that they are correctly constructed, installed and loaded. The arresting of an explosion by a barrier is indeed by no means a simple process but one depending on a correct balance between a number of factors, on which our knowledge is still in many respects empirical, and apparently innocent modifications may impair the efficacy of a barrier. The precautions that should be taken in the installation of barriers are discussed in a paper by H.S. Eisner (Practical aspects of stone-dust barriers. Iron & Coal, April 21, 1961).

The system of protection now recommended was based on knowledge of the performance of the Polish barriers, and of the propagation of coal-dust explosions, gained from work in experimental conditions that of necessity differed somewhat from those in a working mine. However, the expectations regarding the efficacy of the system have been confirmed by the successful operation of the barriers in the explosions at Fenton Colliery, in June 1963, and at Mainsforth Colliery in August of the same year. In both incidents well developed coal-dust explosions were arrested, and in the Fenton explosion it is probable that the loss of life would otherwise have been much greater. A detailed analysis of the behaviour of the barriers in these explosions is given in a paper by H.S. Eisner and F.J. Hartwell (Colliery Guardian, July 17th, 1964).

DIFFICULTIES ARISING IN PRACTICE

In the light of present knowledge and experience, the recommended siting of barriers should be adhered to wherever possible, but it is recognised that it may be difficult or even quite impracticable to do this in certain circumstances.

The main difficulties appear to arise in low and narrow roadways and in rapidly advancing workings. In low and sometimes narrow roads, particularly where in addition to the conveyor itself there may be other equipment such as cables, ducting and mono-rails, conditions are such that a normal barrier would obstruct men traveling or the transport of supplies. Ripping or dinting of the road to accommodate the barrier is costly and in many instances would lag behind the rate of advance of the face. In some places, the rapid advance of the face, together with crush and movement of the roadways, can render the maintenance of barriers in good order and at the recommended distances a difficult problem.

It is therefore evident that, in practice, modifications to overcome these difficulties must be sought and consideration has been and is being given, both in this country and abroad, to the possibility of devising barriers less bulky and more easily erected, capable of being accommodated without obstructing a roadway, and barriers designed to operate successfully at any distance from the point of origin of an explosion.

MODIFICATIONS OF THE PRESENT BARRIER SYSTEM

One modification, namely the use of a barrier of shelves extending over only part of the width of roadway, has been tested by Cybulski in Poland and found to be effective subject to certain provisions. This system could be useful in roads where there was insufficient headroom to install the normal full-width barrier without special ripping and where for various reasons this was not practicable or desirable. It is suggested that in such places part-width barriers sited over the conveyor could be allowed, provided that

(i) the length of the shelves should not be less than 40 % of the width at its widest point;

(ii) there should be sufficient shelves to accommodate the same total quantity of dust as would be required for a normal barrier, preferably in a barrier zone not to exceed the maximum allowed length for a normal barrier;

(iii) longitudinal shelves should be fixed along the length of the barrier zone, on that side of the roadway not covered by the part-width barrier; these should be 6 to 8 inches wide and need not be loose. At least three tiers of such shelves should be provided and as much dust as possible be put on them.

The requirement that the full quantity of dust be provided in the same length of barrier zone as a normal barrier could be achieved by closer spacing of the shelves, subject to the recommended minimum distance apart, or by having two shelves the one above the other.

In certain circumstances, with rapidly advancing faces and headings, it is not always considered practicable to maintain barriers in the road at the recommended distances from the face, and guidance on the maximum distance that could be permitted is desirable. This is particularly desirable if the roads have to be ripped to accommodate a barrier. Unfortunately there is at present little information on this problem, since it has not been possible to test barriers at great distances from the source of an explosion. From such tests as have been made in Poland, by Cybulski, the indications are that the "light" barriers may fail if much further away than the recommended distance of 50 to 120 yards; that if the first barrier is inevitably placed at greater distances than these, it should be of the "intermediate" type, provided that the distance is not greater than 270 yards; and that "heavy" barriers might be expected to be effective at distances somewhat greater than the maximum normally recommended provided half the dust is on the lightly loaded shelves. It is however felt that it would be wise, wherever possible, not to have the first barrier at a distance greater than 400 yards, and for the barrier to be at least of the "intermediate" type.

FURTHER POSSIBLE MODIFICATIONS AND ALTERNATIVES

Among the numerous modifications and types of barriers which have from time to time been suggested are some which are at present being tried out in other countries and some which would appear to merit further study. These include modification to the present Polish barrier by replacing the dust-boards by light plastic troughs, which would facilitate the erection and moving of the barriers, the use of dusts more effective than limestone dust, the use of water instead of dust, and the use of barriers, either of dust or water, designed to be rapidly and positively operated by a trigger mechanism set off by the flame of the advancing explosion.

The choice of dust for barriers

In the past some work was carried out in this country, in France and also in Poland to see whether finely divided common salt, known to be very effective as an explosion suppressant, could be used instead of stone-dust, but it was realised that the use of salt was not practicable on open barriers in mines unless the humidity of the air was so low that the dust would not cake.

It is now normally the practice to use on the barriers the type of dust used for general stone-dusting and, since it is particularly important that the dust will not cake in use, in damp or wet conditions waterproofed limestone-dust is recommended. The waterproofed dust, because the proofing agents are combustible, is slighly less effective than untreated dust in preventing explosions. However, it has been found (Eisner, Maguire and Shaw, 1963) that the incorporation in the proofing agent of certain combustion-inhibiting substances can offset this effect, and it is possible that dust treated in this way may be more effective on barriers than the normal stone-dust.

Water barriers

It had frequently been suggested that finely divided water might be much more effective than stone-dust in extinguishing flame and tests with various forms of water barriers were made as long ago as 1910. Water-trough barriers were tried by Taffanel in 1911, by Czaplinski and Jicinsky in Austria in 1913 and by Beyling in Germany in 1919. Some early tests were also carried out by the Bureau of Mines in America, and some time later (1941) Mayer in Czechoslovakia compared shelf-barriers of stone-dust with troughs of water. These early experiments with water barriers, though few in number, were reasonably successful, but water barriers were not generally adopted in the mines in the countries concerned apart from Austria.

In view of the present-day interest in water barriers it is interesting to note the findings of this early work and the reasons given at that time for discarding water in favour of stone-dust barriers. Generally it was found that the barriers were most effective when the troughs used were such as to be shattered by the explosion, and that there was little difference, weight for weight, between water and stone-dust as extinctive materials. It was thought that the theoretically greater efficacy of water was in practice offset by the facts that it was not easily broken up into fine droplets and that after reaching the floor and sides of a roadway it was not dispersed again by the blast preceding the flame.

The essential objection, both in France and in America, to the adoption of water barriers then was that they would require periodical checking and maintenance, in contrast to a dust barrier which was considered to require little or no maintenance. At that time piped water was not available throughout the mines for replenishing the water troughs, whereas stone-dust barriers were envisaged as being installed in fixed positions.

Under present-day conditions, however, it is generally the opinion that water barriers would be the more convenient. Now piped water is usually available, filling and replenishing the troughs or boxes is quick and easy, movement of a barrier would be comparatively simple, and it might be possible for the barrier to be installed and to be effective in places where it is difficult to accommodate a stone-dust barrier.

In recent years the investigation into the use of water barriers was renewed on the Continent, by Schultze-Rhonhof and by Hanol, and work is still in progress by Steffenhagen and Meerbach and by Cybulski. Recently developed types of water barrier are, in fact, now allowed to be used in mines in Germany.

In the barriers developed by Steffenhagen and Meerbach the troughs are in the form of deep rectangular boxes made of synthetic plastic. These are lighter than timber or metal containers and can be sufficiently translucent for the water level to be seen from the outside. The plastic should not be tough, and although strong enough to stand up to transport and handling should be somewhat brittle so that it is shattered by the blast ahead of the explosion and the water rapidly dispersed. As the throughs are shattered by the blast they need not be installed so as to be moved bodily, as in the case of stone-dust barrier shelves, and hence can be suspended by clamps at their upper edge: lids can also be used if desired.

These barriers have been tested in a variety of conditions, with both strong and moderately weak explosions, and with the troughs disposed in a variety of ways in the experimental mine roadway. They proved successful in arresting the explosions with a water content of about half the weight recommended for a stone-dust barrier. No direct comparison has, however, been reported of the minimum quantity of stone-dust and of water needed to arrest an explosion. It was found that, like the stone-dust barriers, they are not effective when sited too close to the source of the explosion and that the minimum distance from the source should be about the same as for the dust barriers.

It is, however, not yet established whether the barriers would operate so successfully and give adequate dispersion of the water in the case of weak explosions such as those which might conceivably occur in conditions where there was a high level of general stone-dusting, as is the case in this country, and further research is needed. It would also be desirable to obtain more information on the performance of such barriers when sited at comparatively long distances from the source of an explosion.

Triggered Barriers

Many of the difficulties in conveniently accommodating and siting a barrier, and in ensuring that it operated correctly, could perhaps be overcome if, instead of relying on the blast to overturn the barrier and disperse the extinguishing material, one could rely on the mechanical action of a device actuated by a trigger set off by some property of the explosion itself.

Some experiments were made at S.M.R.E., by Allsop and others (1939), in which stone-dust contained in mortars was propelled into the path of an explosion by explosive charges. The charges were fired by a device which consisted of a strip of celluloid which, when burnt by the flame of the explosion, made a contact in the firing circuit. Only few tests were however carried out and the project was not pursued.

At the Bureau of Mines, in America, Hartmann and others carried out tests in which dust contained in paper bags was dispersed in front of explosions by the firing of a cartridge of permissible explosive . Both a thermal relay and a vane-operated contact, placed at some distance in front of the dust bags, were tried as triggers. These tests, made in a variety of conditions in the Experimental Mine, gave promising results, but it was considered that much more work was required before they could seriously be considered for installation underground. Problems to be solved included difficulties of maintenance and the design of a foolproof actuating system.

Experiments made at S.M.R.E., by Shaw and Woodhead, on the suppression of coal-dust explosions by water jets, have provided an idea of the amount of water in the air necessary to arrest an explosion, and could be helpful in the design of triggered water barriers.

Recently it has been reported that triggered barrier systems are being used in Russia. In these the advancing flame of an explosion is detected by a photocell which operates the firing circuit of an explosive device which then, through mechanical linkages, upsets a shelf-type barrier.

Apart from this recent development in Russia, opinion has in the past been in favour of the conventional self-operating barrier on the grounds that the advantages of a trigger-operated system were, in practice, likely to be offset by the need to maintain and regularly check the trigger circuits and mechanism. Modern electronic devices and circuitry are, however, of much increased reliability and are capable of wider applications. Thus it could be possible not only for a trigger device to detect the arrival of the explosion flame but also to sense its speed of advance and to arrange to operate the barrier at the correct time in relation to the speed of the explosion. In view of this the use of triggered barriers may deserve further consideration.

FUTURE DEVELOPMENTS

Because of the many factors involved in the propagation of a dust explosion in a mine and in the mechanism of its suppression by such devices as barriers, these cannot be fully investigated in the laboratory on a model scale. Certain stops in these processes can be isolated and studied separately and useful information obtained, and several such studies are in progress. These include theoretical study of the relation between the blast and the flame in an explosion, investigations carried out on a model scale in shock-tubes of the way dust is raised and barriers disrupted by blast, and a study of the combustion of coal-dust clouds and the effect on the combustion of admixture of inert dusts. In the present state of knowledge, however, a proper assessment of the efficacy of barriers can only be derived from full-scale tests carried out in experimental mines or galleries bearing a reasonable relation, in disposition and size, to conditions in a mine.

Up to the present no facility has been available in this country for such large-scale work on coal-dust explosions, and reliance has had to be placed on work carried out abroad, notably in Germany and Poland. However, the commissioning of the new Coal Dust Explosion Gallery at the Buxton Station of S.M.R.E. has remedied this deficiency and it is hoped will accelerate the development of improved systems of protection against coal-dust explosions.

The new gallery, the longest surface explosion gallery in the world, is 400 yards long and has an arched cross-section of 60 square feet. Near the closest end there is at right-angles to the main gallery a short limb, or "cross-cut", of rectangular cross-section, simulating part of a coal face, which can, when desired, be shut off from the main gallery. Provision is made for instruments to be installed, at intervals of 25 yards, to record the arrival of flame, the development of pressure and of the air-speed of the blast. All instrument signals are recorded on magnetic tape at a central control laboratory.

The main objectives of the work envisaged for the new gallery are to increase our knowledge of the mechanism of coal-dust explosions and to further the development of barrier protection in relation to the requirements of modern mining practice in this country.

Two features of our new facility are of particular importance in the pursuit of these objectives. In past work information has been obtained on the speed of the explosion flame and of the pressures produced in the roadway or gallery, but there is little or no useful experimental information on the strength and development of the wind-speed or blast ahead of the flame on which the operation of conventional barriers depends. The use, in the gallery, of instruments that have been developed for this purpose, by Murray and Beardshall (1958), together with the results of the theoretical and shock-tube studies mentioned previously, should give information that will be useful in assessing the design and siting of barriers.

In addition, the major part of the work so far done on barriers has been in conditions simulating headings, with the explosion propagating from the closed end of a straight gallery, and less is known about conditions similar to those of longwall workings in which there is release of pressure behind the flame provided by the face, goaf and return. The availability of the cross-cut, which is adapted to give variable pressure release, will now enable investigation of the extent to which the explosion and the performance of barriers are affected in such conditions.

To be in a position to make an adequate assessment of a barrier system it is necessary to establish that one can produce in the test gallery explosions varying in character within the range believed to be possible in the mine, and also to what extent these can be reproduced at will, in order to ensure that a sufficient number of tests are made to place proper confidence in the results. It is important that, in producing the experimental explosions, the initiating source used is not such as of itself to cause any disturbance of the barriers under test, and also to check that any reflected shock or pressure waves from the open end of the gallery do not affect the operation of the barrier.

This essential preliminary work is now in progress. In order to produce relatively mild explosions in the gallery earlier work had shown that a relatively mild source of initiation was required and that the dust to be raised in the explosion should contain a fair proportion of inert dust. "Rocket" igniters had been previously found by Shaw to initiate mild explosions in the 4 ft diameter steel galleries and these were therefore chosen for trial as the source of initiation in the new gallery. These igniters, the propellant unit of a commercial firework rocket, when fixed to the floor and fired produce a fast jet of hot gases, extending for a few yards, which raises and ignites the dust. It has already been found that by using a number of these igniters as an initiating source, and by varying the length of gallery over which they can stir up and ignite the dust, the progress of the explosion along the gallery can be varied. In some of the experiments low flame speeds, decreasing in some cases to 35 feet per second, could be obtained over the first 200 yards of the gallery.

Although present indications are that reasonably good reproducibility may be expected, these experiments are still in their early stages and much more exploratory work remains to be done before a worthwhile examination of barrier systems can be undertaken. Factors such as the effect of release of pressure behind the flame, the effect of the roughness produced by arches and lagging and the characteristics of explosions simulating those resulting from unneutralised dust as a conveyor system require to be taken into account.

Until this essential preliminary work is further advanced it is difficult to forecast the future, but it would appear likely that a large number of tests will still be required before it can be said that any new type of barrier or suppressive device, such as for example water barriers, will operate reliably under conditions realistically related to modern mining practice. It should be remembered that the present Polish type barrier, even though it was the culmination of much early work, was itself subjected to well over 100 tests in the experimental mine.

To make a proper assessment of any new suppressive device, however simple, would require it to be subjected to a variety of explosions, ranging from weak to strong, and in each case the tests would have to be made at a range of distances from the source of the explosion. In addition, even if the test explosions could be reproduced with reasonable certainty, several trials in each condition would be desirable to establish the reliability of operation of the device.

Because of the large scale of the work involved it appears unlikely at present that more than two experimental explosions per week could be staged in the new gallery, and in view of the extensive trials that would be necessary, it could therefore be some considerable time before a major change in the present system of barrier protection could be recommended.

Acknowledgement

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PROPOSED COMMUNITY PROGRAMME OF EXPERIMENTS ON STOPPINGS

Draft study programme submitted to the Working Party on "Inflammable Dusts" of the Permanent Commission for Safety in coal mines

This document has been prepared in response to the request made by the Sub-Committee on "Accidents and Testing Stations" of the Working Party on "Inflammable Dusts" at its meeting on 16 May 1966 (items 'd' and 'e' of the Minutes).

In it a test programme is put forward aiming to solve to most urgent problems in the sphere of inflammable dusts. The programme is limited to establishing detailed research goals without going into the working methods which would have to be applied.

I. BASIC STUDY OF DUST EXPLOSIONS

Whatever method of combatting the propagation of a dust explosion may be considered, it would be very useful to know more about the mechanics of the phenomenon and the role played by the factors causing it. Such knowledge is essential, especially so as to be able to apply results gained in a test gallery to mine workings. In addition, such knowledge can be instrumental in suggesting new methods of combatting explosions or, at least, of speeding up research on the improvement of the existing methods: neutralisation and barriers.

Research into the mechanics of this phenomenon can be carried out by three parallel methods:

1) Laboratory tests

The aim is to analyse the different, basic phenomena which contribute to dust explosions, in particular:

a) The ignition and propagation of a flame in a pre-formed dust cloud

The main factors to take into consideration are:

the nature of the coal, size distribution, dust concentration, ash content, addition of inert matter.

b) Raising dust by means of an air current

The main factors to take into consideration are:

the size distribution of the dust, its moisture content, the characteristics of the air jet, the addition of inert matter and fixing agents.

2) Theoretical studies

The aim is to determine the relationship between aerodynamic magnitudes (velocity, pressure) and thermodynamic magnitudes (temperature, velocity, rate of combustion).

Research on this has been started in a single, simple roadway. It would be advisable to follow up this research by studying the problems in a system of more complex geometry.

3) Studies in a full-size roadway

The aim is to try to establish a quantitative description of the phenomena by the measurement of different physical magnitudes.

The magnitudes to be measured should include: air velocity and pressure, velocity of the flame front, shape of the flame front, speed of raising (dispersal) of the dust, the distribution of dust concentrations across the cross-section.

A distinction should be made between the initiation of an explosion and a fully-developed explosion.

Among the factors which it is worth varying, stress should be laid on the shape and the dimensions of the cross-section, the type of supports and the effect of the equipment in the roadway (conveyors, ducting, etc.).

II. STONE-DUST BARRIERS

Stone-dust barriers have been used for a very long time and their effectiveness has been established in many instances. Nevertheless, the following objectives should be aimed at:

1) Extending the field of effectiveness of barriers

Existing barriers do not function reliably:

- in cases of very weak explosions;

- or in cases of very violent explosions which have run some considerable distance.

Attempts could be made to extend the present range of effectiveness by changing:

a) - the size distribution of the material -
Laboratory tests show the advantage of using very fine sizes, but this does not make for good dispersal. An optimum size distribution can only be found by direct tests in a full-size roadway;

b) - the construction and siting of shelves in the cross-section;

c) - the siting of the barriers in the network of roadways and workings (in front of or behind a bend, at what distance from the faces ?).

2) Research into special types of barriers which would fit in with existing equipment for winning work and which would be less inconvenient for the miner (less bulky, easier to place in position). Lateral barriers are one example.

3) Finding a practical method of checking the effectiveness of a barrier on site.

III. WATER BARRIERS

Water barriers are, as yet, infrequently used in mines. Valuable tests have already been carried out at testing stations.

The objectives are the same as those under items 1) and 2) of the preceeding paragraph. It is hoped that water barriers might provide a better solution than stone-dust barriers, i.e.:

- either by a greater field of effectiveness;

- or by being less bulky and easier to place in position.

The main factors which can be varied in an attempt to achieve these objectives are:

a) - the nature of the material of which the troughs are made; shape and method of attachment of these troughs. There is, as yet, no clear-cut preference as between a brittle material, enabling the troughs to shatter easily under the impact of an intense air jet, and a supple material able to discharge without breaking;

b) - positioning of the troughs along the length of the roadway - Specifically, possible distributions are a concentrated one as with existing barriers, or, on the contrary, a very spaced-out semi-continuous distribution along the entire length of the roadways;

c) - addition of soluble salts to the water - Thus it is hoped to reduce the amount of water required;

d) - position of the barriers in the network of roadways and workings - The best position may prove to be different from that of stone-dust barriers.

Objective 3) presents itself in a different way for water barriers. The presence of water can be easily checked. On the other hand, it would be desirable to find a way of reducing the rate of water evaporation.

IV. TRIGGER BARRIERS

The immediate objective is to find a barrier which would be effective in dealing with an explosion initiated in the proximity of a face, be it:

- either, a very weak dust explosion, which has not yet developed;
- or, a gas explosion (without dust) which existing barriers are unable to arrest.

Ultimately, if such barriers were to prove to be sufficiently simple and effective, they could take the place of all existing barriers.

The study consists of three parts:

a) - development of a detector capable of detecting the passage of an explosion;

b) - development of a suppressor device; choice of the extinguishing agent, choice of the method of dispersal, installation in the roadway;

c) - choice of position of the detector and the suppressor device in the working.

V. COMBINATION OF BARRIERS AND OTHER NEUTRALISATION METHODS

It hardly seems necessary to pursue the study of the traditional stone-dusting process, where the limits of effectiveness are more or less known. Yet, the interaction between stone-dusting or dust-fixing method by hygroscopic paste, on the one hand, and barriers, on the other, calls for further studies. To what extent does the application of these processes help or hinder the effective operation of barriers? In what way should they be combined ?

VI. RAPIDLY-INSTALLED BARRIERS

Development of a barrier whose installation would be rapid and which could give protection when fire stoppings are being built.

COMMON ARRANGEMENT OF REPORTS ON TESTS FORMING PART OF THE EXPERIMENTAL WORK ON STOPPINGS TO PROVIDE PROTECTION AGAINST COAL-DUST EXPLOSIONS

Presentation of test results on protective barriers against coal-dust explosions

1. Identification of test

1.1. Type of barrier tested
1.2. Type of explosion (fire-damp and coal-dust explosion or coal-dust explosion).
1.3. Pit in which test was carried out
1.4. Date of test
1.5. Designation of test series
1.6. Number of reference code of test

2. Roadway used (plan attached)

2.1. Local designation
2.2. Length (m)
2.3. Shape of cross-section (circular, arched, trapezoidal, rectangular, etc.)
2.4. Cross-sectional area of the roadway (sq. m.)
2.5. Alignment (rectangular, slightly winding, very winding)
2.6. Profile (horizontal, inclined, variable)
2.7. Intersections in the explosion zone
2.8. Type of supports

3. Coal-dust

3.1. Type of coal
3.2. Size distribution, specific surface (m^2/g, method used)
3.3. Volatile matter - dry basis (%)
3.4. Moisture (%)
3.5. Ash content (%)

4. Dust deposition (section by section)

4.1. Abscissae of the two ends of the roadway
4.2. Dust concentration (in g per cubic metre of roadway)
4.3. Nature of the dust deposit (on the floor, on hurdles along the roadway walls, on shelves, finely dispersed, etc.)
4.4. Means of neutralisation (water, sand, clay, limestone, sea salt, other salts, hygroscopic pastes, etc.)
4.5. Degree of neutralisation (%)

5. Source of explosion

5.1. Ignition of a layer of firedamp in the roof
5.11. Indications of the gas content in the layer at different levels
5.12. Volume of firedamp used (cubic metres)
5.2. Ignition of an explosive mixture of gases
5.21. Nature of the explosive mixture of gases
5.22. Volume of the explosive mixture of gases
5.3. Direct ignition of coal-dust
5.31. Type of initiation
5.32. Positioning and quantity of dust at the point of ignition
5.4. Initiation (explosive, detonator, guncotton, etc.)
5.5. Assessment of the strength of the initiation (weak, medium, powerful)

6. Barrier

6.1. Description of type of barrier, type of suppressant agent
6.2. Type of construction and charge
6.21. Type of construction (type and dimensions of shelves or banks of troughs and troughs, grouped if necessary)
6.22. Number of shelves or banks of troughs
6.23. Total charge (kilograms of suppressant agent)
6.24. Charge per square metre of cross-section (kg/m^2)

6.25. Positioning in the cross-section
6.251. Height
6.252. Possible modifications in the positioning of the barrier in relation to the roadway equipment
6.26. Distance between the shelves or the banks of troughs (in metres)
6.3. Distance between the barrier and the source
6.4. Overall length of the barrier (in metres)
6.5. If necessary, other indications about the placing of the barrier in the roadway (in relation to bends, tapering sectors, intersections, obstacles, etc.)

7. Physical magnitudes relating to the explosion

7.1. Air temperature prior to the test
7.2. Relative humidity (%)
7.3. Atmospheric pressure in the test zone (bars)
7.4. Characteristics of the explosion
7.41. Speed of the pressure wave
7.411. close to the source
7.412. in the barrier zone (in metres per second)
7.413. maximum speed (in metres per second)
7.414. measuring instruments used
7.42. Blast pressure
7.421. close to the source (kN/m^2)
7.422. in the barrier zone (kN/m^2)
7.423. measuring instruments used
7.43. Static over-pressure
7.431. close to the source (kN/m^2)
7.432. in front of the barrier (kN/m^2)
7.433. behind the barrier (kN/m^2)
7.434. measuring instruments used
7.44. Flame velocity
7.441. close to the source (m/s)
7.442. in the barrier zone (m/s)
7.443. beyond the barrier (m/s)
7.444. measuring instruments used
7.45. Travel of flame from the source (m) (measuring instruments used)
7.46. Time elapsing between incipient disposal of the suppressant agent and passage of flame (s) (measuring method)

8. Test results

8.1. Did barrier function (yes or no)
8.2. Condition of barrier after the explosion
8.3. Other significant results

9. Comments

9.1. Estimated distance travelled by flame had there been no barrier
9.2. Other comments

ANNEX IX

IMPLEMENTATION OF RECOMMENDATIONS
OF THE MINES SAFETY AND HEALTH COMMISSION
(AS AT 1.1.1970)

The recommendations, assessments, principles and reports prepared by the Mines Safety Commission since the beginning of its activities and distributed to the Governments and other interested bodies in accordance with its terms of reference, for further action or for information, can usefully be classified in four groups according to their date of issue :

A - the recommendations which are included in the First and Second Reports of the Mines Safety Commission, the implementation of which was published for the last time on the basis of the situation as at 1.1.1966 given in the Third Report,

B - the recommendations which are included in the Third Report of the Mines Safety Commission, the implementation of which was published for the first time on the basis of the situation as at 1.1.1966 in the same Report,

C - the recommendations which are included in the Fourth Report of the Mines Safety and Health Commission, the implementation of which was published for the first time on the basis of the situation as at 1.1.1968 in this Report,

D - the recommendations which are included in the Fifth and Sixth Reports of the Mines Safety and Health Commission for 1967 and 1968 respectively, the implementation of which is published for the first time in the present (7th) Report on the basis of the situation as at 1.1.1970.

The following symbols are used in the tables :

C : The national regulations are already in accordance with the recommendations

C' : The recommendations have not been embodied in regulations, but have been implemented de facto

NRC : New regulations in accordance with the recommendations have been drawn up and issued

NRP : The preparation of new regulations in accordance with the recommendations is in hand

E : The preparation of new regulations is being studied

? : There is uncertainty regarding the steps to be taken

A : The national authorities have abstained from bringing their regulations into line with the recommendations.

To ensure a certain degree of uniformity with regular reports on the measures taken, the following survey shows not only those recommendations which aim at modifying regulations and to this end are indicated by the letters used for the purpose, but also those which need not be implemented by means of regulations or laws. These latter call for other modes of application.

The situation with regard to implementation of the above-mentioned recommendations and proposals is indicated, with explanatory notes, in the following tables.

A - Regular report on the implementation of the Mines Safety and Health Commission's Recommendations published in the 1st and 2nd Reports

I.- TECHNICAL ASPECTS

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Nether-lands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
A.- ELECTRIFICATION												
I - Recommendations regarding elimination of oil from underground electrical equipment (1st Report of Mines Safety Commission, p. 7 (German text))												
2a) Resistances installed underground should not contain any combustible oil. (Exceptions are allowed for the starting-up resistances of large motors driving water pumps).	C	C	NRP	C	NRP	NRC	C'+ E	C'+ NRP	C'	C'	C	C
b) Condensers and transformers installed underground must not contain either combustible oil or dielectric substances which can give off noxious gases.	C	C	NRP	C	NRP	NRC	E	C'+ NRP	C'	C'	NRP	NRP
- Otherwise effective measures should be taken against the dangers to workers caused by the use of these devices.	C	C	C	C	NRP	NRC	C'	C'	C'	C'	NRP	NRP
c) Switches and relays, used underground and operating on voltages below 1.100 V, must not contain any flammable oils.	C	C	NRP	C	NRP	NRC	C'+ NRP	C'+ NRP	C'	C'	NRP	NRP
d) Protection of workers against dangers involved in the use of switches and relays, which work on voltages above 1,100 V and contain flammable oil.	C	C	C	C	NRP	NRC	C	C	C	C	C	C
3. Recommendation to continue research into the manufacture of low-oil or oil-less HT switchgear and protective relays which can give riskfree service in gassy pits.	1) A	1) A	2) -	2) -	3) C'	?	C'+ NRP	C'	2) -	2) -	NRP	NRP
Recommendation to begin detailed investigation into the degree of increased safety which can be achieved, when prescribing an explosion-proof housing for normally spark-producing components only, and a design of the "increased safety" type for all other equipment.	1) A	C	2) -	2) -	3) C'	NRC	4) E	4) E	C	C	NRP	NRP
4. Extending the use of low-oil or oil-less HT switchgear and oil-less HT protective relays at points where there is no gas risk.	1) A	C	C	C	5) NRP	NRC	C'+ NRP	C'	C	C	E	E

1) cannot be laid down in inspectorate regulations.
2) not applicable.
3) devices with satisfactory characteristics exist; the conditions of application must be specified.
4) approval regulations have been issued for equipment in the "increased safety" category, but the type of protection is left to the individual firms.
5) with regard to the approval of certain high-voltage switches.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Netherlands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
II - Recommendations for shotfiring leads (2nd Report of Mines Safety Commission, p. 10)												
2. Recommendations for all shotfiring leads												
- Every conductor must be provided with at least one good-quality insulation.	C	C	C	C	NRC	NRC	C	C	C'	C'	C	C
- All connections must be properly insulated.	C	C	C	C	NRC	NRC	C	C	C'	C'	C	C
- Every shotfiring lead must have the appropriate degree of flexibility.	C	C	C	C	NRC	NRC	C'	C'	C'	C'	C	C
- The conductors must be of such cross-sectional area that they do not occasion an excessive voltage drop.	C	C	C	C	NRC	NRC	C'	C'	C'	C'	C'+ NRP	C'+ NRP
- The shotfiring leads must be made up and laid so that the risk of any fault current, resulting from contact with metal objects, is reduced.	C	C	C	C	NRC	NRC	C	C	C	C	NRP + C	C'+ NRP
- Before any shotfiring operation in particular workings and before the simultaneous firing of a fairly large number of shots, the ohmic resistance of the circuit must be measured.	C	C	C	C	NRC	NRC	C	C	C	C	C	C
a) Temporary shotfiring leads												
- Careful inspection before each firing.	C	C	C	C	NRC	NRC	C	C	C'	C'	C'	C'
- Regular and thorough testing by an expert either at the surface or in an underground workshop.	C	C	C	C	NRC	NRC	C	C	C'	C'	C'	C'
A thorough checking must consist of at least :												
- a careful inspection of the lead over its whole length;	C	C	C	C	NRC	NRC	C	C	C	C	C'+E	C'+E
- measurement of the insulation between the two conductors, if the lead consists of a cable or rubber-covered lead;	C	C	C	C	NRC	NRC	C	C	C	C	C'	C'
- measurement of the ohmic resistance of the lead.	C	C	C	C	NRC	NRC	C	C	C	C	C	C
b) Permanent shotfiring leads												
- Regular and thorough checks by an expert.	C	C	C	C	NRC	NRC	C	C	C'	C'	1) -	1) -
- Written record of every thorough check, with the date.	2) A	2) A	C	C	NRC	NRC	C'	C	C	C'	1) -	1) -

1) not applicable.
2) seems unnecessary and would increase administrative work.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Nether-lands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
3. Further recommendations for permanent and temporary shotfiring leads used in gassy mines												
- The shotfiring leads must fulfil conditions which ensure sufficient safety with regard to :												
a) mechanical strength and in particular tensile, bending and abrasion strength;	C	C	C	C	NRC	NRC	C'	C'	NRP	NRP	C+C'	C+C'
b) electrical insulation;	C	C	C	C	NRC	NRC	C'	C'	NRP	NRP	C+C'	C+C'
c) impermeability (to moisture) of the insulation and the sheathing.	C	C	C	C	NRC	NRC	C'	C'	NRP	NRP	C'+ NRP	C'+ NRP
Recommendation that checking standards which correspond to the conditions be laid down.	C	C	C	C	NRC	NRC	1) -	1) -	NRP	NRP	E	E
4. Supplementary recommendations for permanent shotfiring leads used in gassy pits												
- Permanent leads should be so arranged that, as far as possible, damage during firing of the shots or from other causes is avoided.	C	C	C	C	NRC	NRC	C'	C'	C'	C'	1) -	1) -
- If the shotfiring lead consists of two separate conductors, these should be arranged sufficiently far apart and in such a way that inspection is possible.	C	C	CE	C	NRC	NRC	C'	C'	C'	C'	1) -	1) -
- In shafts and dipping roads, the leads must have an adequate mechanical strength.	C	C	C	C	NRC	NRC	C	C	C	C	C'	C'
III - Recommendations regarding the protection of underground distribution networks against the danger of causing electric shocks (2nd Report of the Mines Safety Commission, p.13)												
I. The following recommendations refer only to the MT networks defined below; Medium Tension (MT) : the normal voltage range for working equipment used underground with three-phase A.C. (between 380 and 1,100 V). These networks should fulfil all the recommendations set out below.												
These recommendations refer neither to the HT networks, nor to voltages which are lower than the medium-tension range and are used for particular purposes (lighting, drilling apparatus, telephone installations, etc.) for which some easing of the restrictions may be allowed. Overhead wire networks with bare trolley wires are also excluded.												

1) not applicable.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Netherlands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
II. Protection against the risk of electric shocks A - First order precautions (Protection against direct contact with a live phase) 1. Every chance contact with a live phase should be avoided as far as possible by laying the conductor out of the workmen's reach, by interposing effective barriers, by sheathing the phase or by insulating it.	C	C	C	C	C	C	C	C	C	C	C	C
2. The cables and leads used in medium-tension underground networks should be mechanically protected either by means of a metal armouring connected to the pilot lead, or by a flexible envelope of the best possible design.	C	C	C	C	C	C	C	C	C	C	C + NRP	C + NRP
- Leads without metal armouring must be electrically protected by separate or common protective screens, which trip safety devices in the event of a fault.	1) C	2) C	C	C	C	C	C	C	C	C	NRP	NRP
3. Only trained men should be allowed to open the housings of accessible live parts (medium-tension voltage range) and this only under conditions which have been clearly laid down in advance.	C	C	C	C	C	C	C	C	C	C	C	C
4. The repair and maintenance of the electrical equipment should be entrusted only to trained personnel.	C	C	C	C	C	C	C	C	C	C	C	C
B - Second order precautions (Equipotential connection between conductive parts of the installation) 1. All underground networks must be provided with an equipotential connection between the conductive (not live in normal operation) components of the installation and the other metal elements connected thereto, such that its conductance is sufficient to prevent the occurrence, between any two points accessible to a workman simultaneously, of a voltage higher than the weak voltage.	C	C	C	C	C	C	C	C	C	C	NRP	NRP

1) in the case of new cables.
2) for old cables, a transitional delay until 1.4.1972 has been provided for.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Nether-lands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
2. This equipotential connection (protective lead) must ensure electric connection between the conductive elements of the installation over the whole length of the network. It must be maintained in satisfactory condition and must be inspected as often as is necessary to ensure this.	C	C	C	C	C	C	C	C	C	C	NRP	NRP
3. The above-mentioned equipotential connection (protective lead) must be earthed to at least one point of the network via an earth connection of the lowest possible resistance.	C	C	C	C	C	C	C	C	C	C	NRP	NRP
4. This earth connection must be combined with the star-point earth connection, if a star-point is employed.	C	C	C	C	C	C	NRP	NRP	C'	C'	NRP	NRP
C - <u>Third order precautions</u> <u>(Reduction of fault duration)</u>												
1. Any fault current must be considered dangerous in underground medium-tension networks if, when the fault current flows through the protective lead and connected conductive components of the installation of earth, there is produced between any two points accessible to a workman simultaneously a voltage exceeding the level of a weak voltage, regardless of whether it occurs between parts of the installation or between such parts and earth.	C	C	C	C	C	C	NRP + C'	NRP + C'	C	C'	C	C
2. <u>If the star-point of a network is earthed via a weak impedance or without any impedance, so that the presumed fault current is not restricted to a low value,</u> then the network must be provided with safety devices which can at any time automatically isolate the damaged section of the network from the current source (or render it completely dead) before the fault current flowing through the protective lead and connected conductive components of the installation or earth reach a dangerous value.	1) -	1) -	1) -	1) -	1) -	1) -	C+ NRP	C+ NRP	E	E	NRP	NRP

1) not applicable, as only isolated circuits are used.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Nether-lands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
- Since the complete or partial cutting-off of a line voltage can have serious effects on the current supply to important equipment, appropriate preventive measures should be taken. - Only when the line has been repaired or the fault eliminated, or at the direction of a specialist who has taken all necessary precautions, may that section of the network be brought under voltage again.	C	C	C	C	NRP	NRP	C+ NRP	C+ NRP	E	E	C	C
3. If the star-point of a network is insulated or earthed via some impedance,which restricts fault currents to a low value, the network must be fitted with supervising devices which are always in a state of readiness and which are capable: a) - either of checking the insulation of the various parts of the network and of indicating any damage they may have suffered or	C	C	C	C	NRP	NRC	C+ NRP	C+ NRP	E	E	NRP	NRP
- of automatically cutting off the damaged section of the network from its source of current (or rendering the entire network dead).	1) -	C 2)	C	C	NRP	NRC	C+ NRP	C+ NRP	E	E	NRP	NRP
- If no automatic cut-off device is installed, the responsibility for cutting-off should be entrusted to an expert who can intervene as soon as the warning signal of the supervisory system is tripped or if the fault assumes major dimensions.	C	C	C	C	NRP	NRP	NRP	NRP	C'	C'	1) -	1) -
- If cutting-off has been necessitated by one of the two cases cited above, the restoration of current may be accepted only after repair of the line or elimination of the fault, or only at the direction of an expert official, who has taken all necessary precautions.	C	C	C	C	NRP	NRC	NRP	NRP	C'	C'	C	C

1) not applicable, as only isolated circuits are used.
2) must be carried out by 1.10.1971 in pits where there is a risk of firedamp.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Nether-lands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
- If no automatic cut-off device is installed, the rubber-covered leads of mobile machines should be fitted with an automatic device which renders them dead as soon as there occurs a fault current which is caused by damage to the external armour or by damage to the insulation of an individual phase;	C	C	C	C	NRP	NRC	C	C	C	C	NRP	NRP
b) - or of automatically cutting off the damaged section of the network from its source of current (or rendering the entire network dead) as soon as a double fault occurs leading to a dangerous fault current in the protective lead and connected parts of the installation. - In this instance, the current may be switched on again only after the line has been repaired or the fault eliminated.	1) -	1) -	1) -	1) -	NRP	NRC	NRP	NRP	C'	C'	NRP	NRP
N.B. The comments on this Recommendation are given in the Second Report of the Mines Safety Commission, pp. 15/22. B.- MECHANISATION AND LOCOMOTIVES I - Recommendations regarding locomotive equipment (First Report of the Safety Commission, p. 20 (German text)) 1. New locomotives must be equipped with fixed, rigid cabins which at all times give the driver a clear view along the roadway, ahead and behind, without any need for him to put his head out of the cabin. (Fixed cabins are understood to cover those forming a part of the structure or which can be removed only laboriously with special tools.)	C 2) A 3)	C 2) A 3)	C 2) A 3)	C 2) A 3)	NRP	NRC	C 4) E 5)	C 4) E 5)	C	C	C	C
2. The locomotives in service must be modified to meet this requirement.	C	C	C	C	NRP	A	E	E	C	C	A	A
- locomotives which cannot be modified should gradually be withdrawn from service, within a period to be fixed by the responsible inspectorate, or	C	C	C	C	NRP	A	E	E	C	C	A	2)

1) not applicable.
2) in the case of main-road locomotives, with the exception of "a clear view behind", which is difficult technically.
3) no application made to gateroad locomotives, because the risk of accident is increased.
4) for trolley locomotives.
5) for other than trolley locomotives.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Netherlands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
- only be used in roadways which are wide and high enough to eliminate accident risk.	C	C	C	C	NRP	C'	E	E	A	A	E	1)
3. For particular types of locomotive, or in certain circumstances, the responsible Inspectorate can grant exceptions from the above regulations, provided that safety regulations of equal stringency are laid down.	C	C	C	C	NRP	NRC	E	E	A	A	E	C
II - Recommendations regarding the neutralisation of Diesel-engine exhaust fumes (First Report of the Safety Commission, p. 23 (German text))												
- General use of better starters.	C	C	E	E	E	E	?	?	?	?	E	C
- Intensified research into improving combustion by the use of catalysts.	A 6)	A 6)	EOP	EOP	E	E	?	?	2)	- 2)	A 2)	A 2)
- Draw attention to the existence of this process.	- 3)	- 3)	- 3)	- 3)	- 3)	- 3)	- 3)	- 3)	- 3)	-	- 3)	- 3)
- Continuation of the research into an automatic transmission system, which would make it possible to give Diesel engines a constant rpm.												
- Subsequent resumption of trials with the Houdry carbon monoxide purification process.	A 2)	A 2)	EOP	EOP	E	E	?	?	2)	- 2)	A 2)	A 2)
C.- FIRES AND UNDERGROUND COMBUSTION												
I - Recommendations regarding equipment for shafts in connection with the prevention of fires (First Report of the Safety Commission, p. 11 (German text))												
2. Steps to prevent any accumulation of grease and coaldust (First Report of the Mines Safety Commission, p. 15 (German text) and Report of the Conference, p. 54, No. 2, para. C.)												
- Skip-winding installations should as far as possible be sited only in upcast shafts;	C'	C'	A 4)	A 4)	E	E	A	A	C'	C'	C'	C'
- Equipment in new shafts should be of aerodynamic form;	C'	C'	C'	C'	E	E	E	E	E	E	C	C
- all suitable steps should be taken to avoid in every case any accumulation of dust to ensure that any such accumulation is removed.	C	C	C	C	NRC	NRC	C	C	C	C	C	C
3. Preferred siting of methane-drainage lines in upcast shafts (First Report of the Mines Safety Commission, p.16 (German text) and Report of the Conference, p. 54, No. 3, Par. d)												
- This recommendation of the Conference applies particularly to pressure lines.	C	C	C	C	NRC	NRC	E	E	5)	- 5)	C	C

1) in the case of main-road locomotives, with the exception of a "clear view behind", which is difficult technically.
2) not suitable for being laid down in inspectorate regulations.
3) not applicable.
4) all skip-winding equipment still in use is installed in downcast shafts.
5) no methane-drainage lines in service.
6) the problem of the low CO content of Diesel engine exhaust fumes is solved by blocking the injection pump at a pumping capacity at which the CO content shows a marked rise.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Netherlands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
4. <u>Siting electric cables, compressed-air mains and gas-drainage pipes</u> (First Report of the Mines Safety Commission, p. 16 (German text) and Report of the Conference, p. 54, No. 3, par. e)												
- electric cables and leads, compressed-air drains and gas-drainage pipes should not be sited in the haulage compartment:	C	C	C	C	NRC	NRC	E	E	C'	C'	C	C
- electric cables should not all be sited in the same shaft.	C	C	C	C	NRC	NRC	E	E	C'	C'	C	C
II - <u>Guiding principles for fighting mine fires by sending down water (Second Report of the Mines Safety Commission, p. 26)</u>												
1. <u>Installation</u>												
a) At the top of every shaft reaching to the surface there must be a device which can send down at least 50 litres of water per minute and per square metre of shaft cross-section.	C	C	C	C	NRC	NRC	E	E	E	E	C	C
b) This device must be installed in such a way that the supply of water can at no time be seriously affected by drawing-off or flowing-away of water at other points.	C	C	C	C	NRC	NRC	E	E	E	E	C	C
c) The water pipes and the spray jets must be set in such a way that they are protected from frost.	C	C	C	C	NRC	NRC	E	E	E	E	C	C
d) The damming device or devices must be set outside the shaft-top building in such a way that they can be operated at any time. They must be marked by means of an instruction plate.	C	C	C	C	NRC	NRC	E	E	E	E	C	C
2. <u>Fires in down-cast shafts</u>												
a) <u>Immediate measures</u>												
- it is essential to indicate in the fire-fighting plan the maximum amount of water which can be sent down each of the down-cast shafts, without creating additional dangers for the workers by its effects on the ventilation.	A 1)	A 1)	A 2)	A 2)	E	E	E	E	E	E	E	C
- the damming device which can be operated at this stage must not release more than this prescribed quantity of water.	A 3)	A 3)	A 2)	A 2)	E	E	E	E	E	E	E	C

1) there are doubts as to the practicability of the Recommendation; minimum water quantities are laid down.
2) not suitable for inclusion in regulations.
3) there are doubts as to the practicability of the Recommendation.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Netherlands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
- until the leader of the rescue operations has issued his instructions and as long as there has been no reversal of ventilation, water may be sent down only by opening the damming device prescribed for this purpose.	A 1)	A 1)	A 2)	A 2)	E	E	E	E	E	E	E	C
b) <u>Measures to be taken on the instructions of the leader of rescue operations</u> - the leader of the rescue operations must therefore decide - taking into account all the circumstances - either to send down an increased quantity of water - or he must give orders that reversal of the ventilation be brought about or encouraged.	A 2)	A 2)	A 2)	A 2)	E	E	E	E	E	E	E	C
- to facilitate the reversal of the ventilation in the burning downcast shaft, once this has been opened and the main fan stopped, water can be sent down the upcast shaft.	C	C	C'	C'	E	E	E	E	E	E	C	C
- if reversal of the ventilation has already occurred - either as a result of the upward current produced by the heat of the fire or deliberately - downcast shafts should be treated as though they were upcast shafts.	C	C	C'	C'	E	E	E	E	E	E	C	C
- if the calculated water quantity appears to be too small to extinguish the fire immediately, or to hinder its spread, additional precautions must be worked out and laid down in the fire-fighting plan: - simultaneous supply of water down all downcast shafts,	A 2)	A 2)	A 2)	A 2)	E	E	E	E	E	E	E	C
- partial shutting-off of the burning shaft at surface level,	A 3)	A 3)	A 3)	A 3)	NRC	NRC	E	E	E	E	E	C
- shut underground fire-doors, etc.	A 3)	A 3)	C	C	E	E	E	E	E	E	E	C
3. <u>Fires in upcast shafts</u> - in upcast shafts, water may be sent down only on the instructions of the leader of the rescue operation.	C	C	C	C	E	E	E	E	E	E	C	C
- as long as there are still any workers in the pit, only so much water may be sent down as will allow the fumes of the fire to continue to be extracted whilst the water is falling.	C	C	C	C	E	E	E	E	E	E	C	C

1) there are doubts as to the practicability of the Recommendation.
2) not suitable for inclusion in regulations.
3) not suitable for inclusion in regulations; must be decided separately in each case.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Netherlands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
Note. A commentary and examples (with diagrams), regarding the calculation of the effect of falling water on the ventilation are given in the Second Report of the Mines Safety Commission, pp. 29-50. III - Recommendations for the sealing-off by dams of mine fires and underground combustion (Second Report of the Mines Safety Commission, p. 53) Introductory remark The following Recommendations are not binding. They are not intended to give Inspectorates "ready-made" regulations; on the contrary, it remains for the competent authorities to decide how these Recommendations are to be applied as regulations, circulars or service instructions. These Recommendations refer only to the actual fighting of the fire or combustion; they do not refer to the measures to be taken as a matter of priority to rescue men following the outbreak. A - When a mine fire has broken out or underground combustion developed, it is indispensable to take the necessary preparatory steps for any later sealing-off by dams which may be necessary while the direct fire-fighting operations are still going on.	C	C	C	C	NRC	NRC	C'	C'	C'	C'	C	C
- In the event of sealing-off by dam becoming necessary, as a general rule the first stoppings to be erected must be advance dams.	C	C	C	C	NRC	NRC	C'	C'	C'	C'	C	C
These advance dams are in fact the real subject of the present Recommendations. B - Structure and erection of the advance dams 1. If there is no risk of explosion (1): a) to make the advance dams themselves as air-tight as possible and to create the closest possible seal between the dam and the surrounding walls;	C	C	C	C	NRC	NRC	C'	C'	E	E	C	C
b) there is nothing against shutting off first of all the intake air.	C	C	C	C	NRC	NRC	C'	C'	E	E	C	C
2. If there is a risk of explosion: a) - to have at all times the most precise information possible regarding the degree of explosion risks in the fire zone;	C	C	C	C	NRC	NRC	C'	C'	E	E	C	C

1) for the assessment of the risk, see chapter A - II a), p. 52.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Nether-lands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
- it may be necessary to provide the men constructing the advance dams with fire-proof clothing;	C	C	C	C	E	E	C'	C'	E	E	C	C
b) - to ensure that the advance dams are as air-tight as possible;	C	C	C	C	NRC	NRC	C'	C'	E	E	C	C
- to ensure that they are strong enough to resist an explosion;	C	C	C	C	NRC	NRC	C'	C'	E	E	C	C
c) - to ensure that for the entire period during which the stopping is being erected, there is sufficient ventilation of the fire zone to counter as far as absolutely possible the formation of an explosive gas mixture;	C	C	C	C	NRC	NRC	C'	C'	E	E	C	C
d) - to ensure that all suitable measures are taken to reduce as far as possible the effects of any explosion which may occur; (dust barriers, stone-dusting or water trough barriers);	C	C	C	C	NRC	NRC	C'	C'	E	E	C	C
e) - to the greatest possible extent, the dams on the intake and return sides should be sealed simultaneously;	C	C	C	C	NRC	NRC	C'	C'	E	E	C	C
- only the number of workers and members of the staff strictly necessary for this work should stay behind;	C	C	C	C	NRC	NRC	C'	C'	E	E	C	C
- as soon as the dams have been sealed, the danger area must be completely evacuated.	C	C	C	C	NRC	NRC	C'	C'	E	E	C	C
C - <u>The final dams</u> must be durable, <u>built of brick</u> or concrete under the protection offered by the advance dams.	C	C	C	C	NRC	NRC	C'	C'	E	E	C	C
<u>Note</u>: Additional details to the foregoing Recommendations are given in a Commentary (Second Report of the Mines Safety Commission, pp. 53/58).												

II.- HUMAN FACTORS

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Netherlands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
A.- RECOMMENDATIONS REGARDING MEDICAL EXAMINATION (SECOND REPORT OF THE MINES SAFETY COMMISSION, p. 79)												
I - Pre-Entry Medical Examinations												
- All applicants for employment at collieries should undergo a pre-entry medical examination.	C	C	C	C	C	C	C	C	C	C	C	C
- This must establish that the applicant shows no symptoms rendering him unfit for such employment.	C	C	C	C	C	C	C	C	C	C	C	C
The pre-entry medical examination must include: - a general examination - such special examination as may be deemed necessary for the purpose.	C	C	C	C	C	C	C	C	C	C	C	C
- The examinations effected must include, as regards the chest, a radiograph or radiophotograph of format not smaller than 70 x 70 mm;	C	C	C	C	C	C	C	C	C	C	C	C
- the latter to be supplemented if need be by a standard-format (1 : 1) radiophotograph;	C	C	C	C	C	C	C	C	C'	C'	C	C
- The nature of these examinations and	C	C	C	C	C	C	C	C	C'	C'	C	C
- the practical details, together with	C	C	C	C	C	C	C	C	C'	C'	C	C
- the criteria on which the doctor should base his findings,	C	C	C	C	C	C	C	C	C'	C'	C	C
- should be defined by medical experts.	C	C	C	C	C	C	C	C	C'	C'	C	C
- In the case of recruitment for work, whether below or above ground, where the worker will be exposed to a dust hazard, the examination must show a normal pulmonary image.	C	C	C	C	C	C	C'	C'	C'	C'	C	C
- The concept of normal pulmonary image must be defined by medical experts.	C	C	C	C	C	C	C'	C'	C'	C'	C	C
- These are to be regarded as minimum medical recommendations.												
- The points concerning the number and type of examinations to be carried out,												
- the effecting of radiological examinations												
- the definition of the normal pulmonary image												
- are subject to review in each country												
- whenever this is felt to be appropriate in the light of progress in medical and radiological knowledge												
- working conditions, and												
- preventive measures.												

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Nether-lands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
II - Special Examinations												
1. The object of special medical examinations should be to establish - taking into account, according to circumstances, the opinions of - the training	C	C	C	C	NRP	NRP	C'	C'	E	E	C	C
- vocational-guidance and applied psychology	C	C	C	C	NRP	NRP	C'	C'	E	E	C'	C'
- and other services concerned a worker's fitness for certain specific occupations.	C	C	C	C	NRP	NRP	C	C	C	C	C	C
2. Such examinations are essential in the case of jobs												
- which, either in themselves or owing to the conditions under which they are performed, involve a special hazard to the worker himself or to others as regards health and/or safety,	C	C	C	C	NRP	NRP	C	C	C	C	C	C
- which involve special health or safety requirements,												
- or which demand particular physical aptitudes or characterological qualities.	C	C	C	C	NRP	NRP	C	C	C	C	C	C
3. No attempt has been made here to list in full the cases in which special examinations are necessary, this being left to the competent authorities in each country. Examples include:												
- winding enginemen,												
- staple pit enginemen,												
- motormen (drivers of locomotives, mobile haulers and surface vehicles),												
- workers assigned to hot workings,												
- all those employed on cage handling.												
III - Routine examinations during employment												
A - Periodic health checks												
- The object here is to establish whether the subject is still fit for duty,	-	C	C	C	C	C	C	C	C	C	C	C
- to detect any symptoms of occupational disease at the earliest possible stage,	-	C	C	C	C	C	C	C	C'	C'	C	C
- where appropriate to help supervise the subject's health generally.	-	C	C	C	C	C	C	C	C'	C'	C	C
- All personnel should undergo such check-ups at intervals.	C'	C'	C	C	C	C	C	C	C	C	C	C

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Netherlands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
- The interval is fixed at two years.	C	C	NRC	NRC	C	C	C 1)	C 1)	C 2)	C 2)	C	C
- The interval is reduced for workers under 21.	C	C	NRC	C	C	C	C 3)	C 3)	C	C	E	NRP
- The interval should be considered as a maximum figure.	C	C	- 4)	- 4)	- 4)	- 4)	C	C	C	C	C	C
This interval can also be reduced:												
- if the state of health of a worker indicates that such a reduction is desirable;	C	C	C	C	C	C	C	C	C'	C'	C'	C'
- in relation to the type of work performed;	C	C	C	C	NRP	NRP	C	C	E	E	C	C
- because of the nature of the place at which the work is being done.	C	C	C	C	NRP	NRP	C	C	E	E	C	C
B - Medical examinations on specific occasions												
1. In the case of reassignment												
- Workers whom it is proposed to assign to jobs involving hazards not previously taken into account for the man concerned should be re-examined.	C	C	C	C	NRP	NRP	C	C	E	E	E	C
2. Medical examination following absence from work												
- Where a man's return to work after an illness or accident involves risk to the safety of himself or others, he may be subjected to a special examination,	C	C	C'	C'	NRP	NRP	NRP +C'	C	E	E	C'	C'
- the type and extent of which should be fixed in each case according to the circumstances.	C	C	C'	C'	NRP	NRP	C'	C'	E	E	C'	C'

1) the interval is one year.
2) article 648 of Inspectorate Regulations provides for an interval of one year.
3) for workers under 18 years of age.
4) not applicable.

B - Regular Report on the implementation of the Mines Safety and Health Commission's Recommendations published in the Third Report

I - TECHNICAL ASPECTS

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Netherlands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
I - Recommendations regarding the protection of underground electrical networks against fire and firedamp-explosion risks (Doc. 1156/61/4)												
1. Recommendations regarding the protection of underground electrical networks against fire risk												
A - First-order precautions - avoidance of fire risk												
1) Avoidance of excessive heating of cables in normal use by providing adequate conductivity. Avoidance of unforeseen local heatings by the use of suitable designs and by proper supervision.	C	C	C	C	C	C	C	C	C	C	C + NRP	C + NRP
2) Reduce the possibility of faults and short-circuits occurring between conductors, or between conductor and earth, by adequate insulation or proper spacing of the conductors.	C	C	C	C	C	C	C	C	C'	C'	C + NRP	C + NRP
B - Second-order precautions - protection against the effects of a heating or a fault												
1) Use of heat-stable insulations.	C	C	C	C	C	C	NRP	NRP	C'	C'	C + NRP	C + NRP
2) Use of protective sheathing for equipment and for cables, made of flame-resistant and non-propagating material.	C	C	C	C	NRP	NRC	C 1)	C 1) + NRP	C'	C'	C + NRP	C + NRP
- Use of oil as a non-conductor only if no fire risk for the workers is involved.	C	C	C	C	NRP	NRP	C	C	C'	C'	C + NRP	C + NRP
3) Accumulations of flammable or combustible materials and pipelines for combustible gases should be sited well away from electrical equipment.	C	C+C'	C+C'	C+C'	C	C	C'+ NRP	C'+ NRP	C'	C'	C + NRP	C + NRP
C - Third-order precautions - measures regarding the network												
1) Automatic protection of networks against abnormal overloads.	C	C	C	C	C	C	C	C	C	C	C + NRP	C + NRP

1) with respect to armoured cables.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Nether-lands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
2) Automatic protection of networks against short-circuit; these protective devices must be capable of handling the maximum short-circuit current at their point of installation.	C	C	C	C	C	C	NRP	NRP	C'	C	C + NRP	C + NRP
Selecting and regulating of these devices in relation to the minimum short-circuit current which can occur at the end of the section they protect.	C	C	C	C	C	C	NRP	NRP	C'	C'	C + NRP	C + NRP
3) Steps to give effective protection against low-current faults, which might get past the above-named protective devices and cause dangerous heatings.	NRP	C[1]	NRP	NRP	NRP	NRP	C	C	C'	C'	C'+ NRP	C'+ NRP
2. Recommendations for the protection of underground electrical networks against firedamp-explosion risks												
A. First-order precautions - prevention of accumulations of firedamp												
1) The firedamp content at the site of the electrical apparatus must be kept within the limits prescribed by the Inspectorate.	C	C	C	C	C	C	C	C	C	C	C	C
2) The ventilation situation must be checked before any new installation or extension of electrical equipment.	C	C	C	C	C	C	C	C	C'	C'	C'+ NRP	C + NRP
3) There must be a thorough investigation of the possible consequences of any alterations in working method, of ventilation or gas omission, which might cause problems in the vicinity of electrical equipment.	C	C	C	C	NRP	NRC	C	C	C'	C'	C'	C'
B. Second-order precautions - protection against ignition												
1) In gassy workings: use of electrical equipment which is permitted by the Inspectorate only under its own specified conditions.	C	C	C	C	C	C	C	C	C	C	C + NRP	C + NRP
2) The electrical equipment must be installed, used, supervised and maintained in such a way as to keep it flameproof.	C	C	C	C	C	C	C	C	C	C	C + NRP	C + NRP
All cables must be of adequate mechanical strength.	C	C	C	C	C	C	C	C	C	C	C + NRP	C + NRP
All cables must be installed and maintained without damage.	C	C	C	C	C	C	C	C	C	C	C	C

1) must be carried out by 1.10.1971 in pits where there is a risk of firedamp.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Netherlands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
C. <u>Third-order precautions - cutting off the circuit</u>												
1) Networks must be designed and installed in such a way that any fault current which may arise between phase and earth is reduced to a low value or quickly cut off.	NRP	C 4)	C	C	NRP	NRC	C	C	C	C	C + NRP	C + NRP
2) A protective relay, preferable automatic, must be provided against between-phase faults and earth faults.	NRP	C 4)	C 1)+ NRP	C	NRP	NRC	C	C	C	C	C'+ NRP	C'+ NRP
3) Precautions must be taken to avoid accidents when faults are being sought or dealt with.	C	C	C	C	NRP	NRC	C	C	C	C	CC'+ NRP	CC'+ NRP
4) Protection must be given to leads without metallic sheathing, and to those which supply movable machines, by means of individual or collective screens which bring a protective device into operation if a fault occurs.	C	C	C	C	C + NRP	NRC	C	C	C	C	C'+ NRP	C'+ NRP
5) If the firedamp content rises above the prescribed limit, all the sections of the network involved must be cut off.	C	C	C	C	C	C	C	C	C	C	C	C
Issuing instructions to maintain in operation certain machines which provide ventilation.	C	C	C	C	C	C	C	C	C	C	C+C'	C+C'
Restarting only when the firedamp content has fallen below the permissible value, and only on the orders of a trained person.	C	C	C	C	NRP	NRP	C	C	C	C	C + NRP	C + NRP
<u>Supplementary precautions for pits liable to sudden outbursts of gas</u>												
1. <u>Risk of damage by particles projected by an outburst of gas</u>												
- The threatened zones in which projection can occur should not be electrified.	A	A	C	C	NRP	NRC	C 2)	C 2)	C 3)	C 3)	A	A
- The electrical equipment and cables should be protected against heavy blows.	A	A	C	C	C	C	C	C	C 3)	C 3)	C	C
- The electrical equipment should be designed to give adequate robustness.	A	A	C	C	C	C	C	C	C 3)	C 3)	C	C

1) available for movable equipment.
2) the use of electricity is forbidden in pits liable to sudden outbursts of gas, excepting for lighting and shot-firing. Exceptions can, however, be approved by the senior mining engineers: when using armoured cables, telephone installations and methanometers in intake airways - provided that no damage is likely to occur as a result of a gas outburst - and also in main return airways.
3) No pits liable to sudden outbursts of gas. However, in pits or parts of mines which are considered to be liable to sudden outbursts of gas, the use of electricity, excepting for lighting purposes and portable lamps, must be authorized by a senior mining engineer, subject to the observance of all other measures, precautions or restrictions which might be included in the authorization such as for example the above-mentioned recommendations.
4) must be carried out by 1.10.1971 in pits where there is a risk of firedamp.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Nether-lands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
2. <u>The risk of firedamp concentrations</u>												
- Increased ventilation	C'	C'	C'	C'	C'	C'	C	C	C 1)	C 1)	C	C
- Use of remote-indicating methanometers or ventilation-fault detectors which can cut off the threatened section of the network	C'	C'	E 2)	C'	E	E	C	C	C 1)	C 1)	C'+ NRP	C + NRP
- Relaxation shot-firing only after all equipment has been switched off.	C'	C'	C'	C'	NRP	NRC	C	C	C 1)	C 1)	-	-
3. <u>Supplementary electrical precautions</u>												
a) Preferable use of a starpoint earthed via a strong impedance, e.g. by means of an insulation detector.	C	C	C	C	NRP	NRC	NRP	C'+ NRP	C 1)	C 1)	NRP	NRP
b) Quickest possible automatic protection of the network against all insulation faults, even if formed by resistances between phase and earth.	NRP	C 4)	C + NRP	C + NRP	NRP	NRC	C	C	C 1)	C 1)	C + NRP	C + NRP
II - <u>General guidelines for the opening-up of sealed-off fire areas (Doc. 1304/3/64)</u>												
I. <u>GENERAL</u>							3)	3)				
Special reasons for opening-up a district sealed-off after a fire: - recovery of bodies - salvage of material - recovery of roadways and workings - reduction of the sealed-off area - inspection of the district, and, if necessary, - direct fire-fighting. The following hazards can arise from reopening a sealed-off district: - release of CO, foul air and hot damp air, - explosion of firedamp or fire gas, where the fire is not yet extinguished, - recrudescence of the fire, which need not necessarily occur immediately, but even after some time has elapsed. Recrudescence of the fire can occur only when fresh air reaches the seat of the fire, so that with all operations involved in reopening a fire area it is of prime importance to inspect the individual air currents constantly.	C	C	C	C	C	C	C'	C'	C'	C'	NRP	C'

1) no pits liable to sudden outbursts of gas. (See note 3, previous page).
2) already applied in individual cases.
3) the opening-up of fire areas is carried out on the responsibility of the manager, who prepares a reopening plan - taking into account the scale and type of fire and the ventilation situation in the fire area - in collaboration with the Main Rescue Station. The action plans of the Main Rescue Stations very largely embody the guidelines laid down in Doc. 1304/3/64 .
4) must be carried out by 1.10.1970 in low-tension networks.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Netherlands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
All places suspected of having been seats of fire or heatings must be ascertained with the utmost speed.	NRP	NRP	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'
II. BASIC RULES												
Sealed-off districts may be reopened only after the competent authorities have been notified or have given their permission.	C	C	C	C	C	C	C 1)	C 1)	C 1)	C 1)	C'	C'
Before opening commences, gas samples must be taken from the fire area, at each stopping and from all sampling pipes.	C	C	C	C	C	C	C'	C'	C	C	C'	C'
The gas samples are analysed and the results assessed from the point of view of explosion risk in the sealed-off area and the state of the seat of the fire.	C	C	C	C	C	C	C'	C'	C	C	C'	C'
The cooling-off time of the seat of the fire must be taken into account.	NRP	NRP	C	C	C'	C'	C'	C'	C'	C'	C'	C'
If possible, the sealed-off district should be inspected before any air is circulated or any operations are started.	A	A	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'
Before opening commences, a plan should be drawn up jointly with the Main Rescue Centre.	C	C	C	C	C'	C'	C'	C'	C'	C'	C'	C'
This plan must cover the following points: - the method, - nature, scope and order of operations, - direction and supervision, - checking of the ventilation system and of the composition of the air, - communications, - preparation of material, - evacuation, prohibition of access to and remanning of endangered workings, - deployment of the Rescue Team, - connection and disconnection of electrical equipment and cutting-off the supply of electricity in both equipment and part of network concerned, - opening and closing of the compressed air, water and methane-drainage pipeline valves, - re-sealing of the fire area in emergency.	C	C	C	C	C'	C'	C'	C'	C'	C'	C'	C'
The method to be adopted for reopening sealed-off districts depends on the presence or otherwise of - non-explosive gaseous mixtures which remain non-explosive on dilution with air, - non-explosive gaseous mixtures which may become explosive on dilution with air, or - explosive gaseous mixtures.												

1) applies only to the opening-up of fire areas after particularly large fires.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Nether-lands	
	1.1.1968	1.1.1970	1.1.1968	1.1.1970	1.1.1968	1.1.1970	1.1.1968	1.1.1970	1.1.1968	1.1.1970	1.1.1968	1.1.1970
Fire areas may be opened at one point or at several points. In the latter case, a continuous direct circulation of air is automatically established and the fire area is permeated with fresh air. An examination should be made of the effects of the opening of the area on the ventilation system of the pit as a whole and within the fire area.	C	C	C'+C	C'+C	C'	C'	C'	C'	C'	C'	C'	C'
A sealed-off district may be re-opened by - breaching one or more stoppings (with or without the use of an air-lock), or - cutting a new entry into the fire-area. Before opening a sealed-off area, provision should be made for immediate reclosure if necessary.	C	C	C	C	C	C	C'	C'	C'	C'	C'	C'
Stoppings may be opened only on the instructions of the manager underground and under the constant supervision of personnel appointed by him.	C	C	C	C	C'	C'	C	C	C	C	C'	C'
Workings, into which the opening of a stopping may release toxic gases or foul air, or where there is a risk of explosion, must be evacuated and put out of bounds to personnel before opening.	C	C	C	C	C'	C'	C	C	C'	C'	C	C
Since conditions in the district, the state of the seat of the fire and the risk of gas explosion may change during the opening operation the composition of the fire gases or fumes must be checked at regular intervals.	C	C	C	C	C	C	C	C	C'	C'	C'	C'
The kind and number of samples and the points at which they are to be taken should be fixed in advance.	C	C	C	C	C'	C'	C'	C'	C'	C'	C'	C'
In doing so, the possibility of gas accumulations forming should be allowed for. (In general, the formation of gas layers is fostered by low air velocities and differences in temperature.)	C	C	C	C	C'	C'	C'	C'	C'	C	C	C
Where a stopping is opened in the knowledge that a fire is not yet extinguished, or where the fire is revived as a result, the area in question must be resealed at once, if the composition of the fire gases or fumes changes in such a way that an explosion hazard might arise.	C	C	C	C	C'	C'	C'	C'	C'	C'	C'	C'
With non-explosive gas mixtures in the fire area, this is necessary only if extinguishing operations seem unlikely to succeed.	C	C	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'
It is the responsibility of the Rescue Team to open and inspect fire areas, even after they have been ventilated.	C	C	C	C	C'	C'	C'	C'	C'	C'	C'	C'

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Nether-lands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
On the intake side, breaching of stoppings need not be carried out by the Rescue Team provided that no gas hazard is to be reckoned with.	C	C	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'
When deploying the Rescue Team, allowance should be made for the adverse climatic conditions which are likely to obtain at any point where they may be employed.	C	C	C	C	C'	C'	C	C	C'	C'	C	C
III. <u>OPENING-UP SEALED-OFF DISTRICTS CONTAINING NON-EXPLOSIVE GAS MIXTURES</u> 1. <u>Opening-up one side only</u> A sealed-off district containing non-explosive gas mixtures may be opened on one side even if the fire is not yet extinguished. It must first be established whether the remaining stoppings and seals are sufficiently airtight and that there is no risk of releasing fire gases, in particular carbon monoxide in other parts of the working, which may be connected with the fire area.	C	C	C	C	C'	C'	C'	C'	C'	C'	C'	C'
If the stopping to be opened is on the return side, special attention should be paid to the release of CO or of other toxic or dangerous gases or foul air.	C	C	C	C	C	C'	C	C	C'	C'	C'	C'
The decision as to whether to carry out operations in the fire area without ventilation air or with auxiliary ventilation depends on the purpose of the reopening of the area, the expected duration of the Rescue Team's operations and the possible hazards involved. Auxiliary ventilation is especially desirable for extended operations within the fire area. a) Working without ventilation air, especially behind an airlock, has the advantage of eliminating the risk of reviving the fire. When carrying out extinguishing operations without ventilation air and under unfavourable air conditions, it is advisable first to set up water sprinklers or nozzles and to put these into operation only after the Rescue Team has left the fire area.	C	C	C	C	C'	C'	C'	C'	C'	C'	C'	C'
b) If auxiliary ventilation is used, it should preferably be by suction.	C	C	A 1)	A 1)	C'	C'	C'	C'	2)	- 2)	C'	C'

1) experience hitherto has shown that blowing auxiliary ventilation is preferable, to ensure that no explosive gases are sucked in by the auxiliary fan.
2) the use of blowing auxiliary ventilation is preferred.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Nether-lands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
It is advisable to isolate the fire area ventilated by an auxiliary fan from the non-ventilated section by means of an auxiliary stopping if the seat of the fire is situated in the non-ventilated section.	C	C	C	C	C'	C'	C'	C'	C'	C'	C'	C'
2. <u>Opening on two sides to establish a circulation of air round the sealed-off area</u> A sealed-off area containing non-explosive gas mixtures may be ventilated only if it is likely that the fire is extinct.	C	C	C	C	C'	C'	C'	C'	C'	C'	C'	C'
While ventilation is being established, a Rescue Team wearing breathing apparatus may enter the fire area to examine conditions within it and to extinguish any fires.	C	C	C	C	C'	C'	C'	C'	C'	C'	C'	C'
IV. <u>REOPENING OF SEALED-OFF DISTRICTS CONTAINING GAS MIXTURES WHICH MAY BECOME EXPLOSIVE ON DILUTION WITH AIR</u> 1. <u>Opening on one side only</u> A sealed-off area containing gas mixtures which may become explosive on dilution with air may be opened on one side only, even if the fire is not yet extinguished. It is, however, essential to install a tight airlock in front of the stopping to be opened, so as to ensure an effective air seal.	C	C	C	C	C'	C'	C'	C'	C'	C'	C'	C'
It must first be checked whether the remaining stoppings and seals are sufficiently air-tight and that there is no risk of releasing fire gases, in particular carbon monoxide, into other parts of the workings which may be connected with the fire area.	C	C	C	C	C'	C'	C'	C'	C'	C'	C'	C'
If the stopping to be opened is on the return side, particular attention must be paid to the possibility of releasing CO, CH_4 or foul air	C	C	C	C	C'	C'	C	C	C'	C'	C'	C'
All operations must be carried out without ventilation air.	C	C	C	C	C'	C'	C	C	C'	C'	C'	C'
There must be continuous sampling and evaluation of the results of analysis to check whether the gas mixture remains non-explosive.	C	C	C	C	C'	C'	C	C	C'	C'	C'	C'
For extinguishing operations, see section III.1.												

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Netherlands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
If the size of the sealed-off area is to be reduced, a new explosion-proof stopping must be erected. In order to be able to erect this stopping under tolerable climatic conditions and possibly without wearing breathing apparatus, auxiliary ventilation may have to be provided.	C	C	C	C	C'	C'	C'	C'	C'	C'	C'	C'
For this purpose, an auxiliary stopping must first be erected and sealed in an unventilated atmosphere. (Before constructing the main stopping, it should be considered whether to erect several successive auxiliary stoppings, according to the possible hazards.)	C	C	C	C	C'	C'	C'	C'	C'	C'	C'	C'
The section of roadway thus recovered must then be ventilated by an auxiliary fan so as to create suitable air conditions for the erection of the main stopping.	C	C	C	C	C'	C'	C'	C'	C'	C'	C'	C'
When starting up the auxiliary ventilation, it must be remembered that the gas mixture becomes explosive on dilution with air. It is therefore essential to ensure that there is no source of ignition in the workings to be ventilated.	C	C	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'
In addition, it is essential to make certain that the fan used cannot cause any risk of ignition.	C	C	C	C	C'	C'	C'	C'	C'	C'	C'	C'
Before starting up the auxiliary ventilation, all workings likely to be exposed to the hazards of fire gases or explosions must first be evacuated and access thereto prohibited.	C	C	C	C	C'	C'	C'	C'	C'	C'	C'	C'
Electrical equipment must be cut off from the power supply.	C	C	C	C	C	C'	C'	C'	C'1)	C'1)	C'	C'
In addition, the ventilation must, as far as possible, be regulated so that no explosive gas mixtures can be released over long distances.	C	C	C	C	C'	C'	C'	C'	C'	C'	C'	C'
For this purpose, the quantity of air circulated should, if necessary, be increased.	C	C	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'
2. <u>Opening on two sides to establish a circulation of air through the fire area</u> This method of opening automatically results in the formation of a through air-current in the open district, but not necessarily in other parts of the district. The method can be used only if there are no remaining signs of fire in the district.	C	C	C	C	C'	C'	C'	C'	C'	C'	C'	C'

1) special attention is drawn to the fact that the fan must be switched off.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Nether-lands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
In addition, a period long enough for the seat of the fire to cool off must have elapsed since the estimated time of extinction.	C	C	C	C	C'	C'	C'	C'	C'	C'	C'	C'
If possible, the Rescue Team should carry out an inspection in an unventilated atmosphere.	A	A	C	C	C'	C'	C'	C'	C'	C'	C'	C'
Failing this, the results of the snuffle pipe tests should be used to determine the condition of the seat of the fire.	C	C	C	C	C'	C'	C'	C'	C'	C'	C'	C'
Furthermore, it should be considered in such cases whether the method described in section IV.1 might not be preferable.	NRP	NRP	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'
In each case, it is essential to check the likelihood of a recrudescence of the fire during ventilation, by means of fire gas samples.	C	C	C	C	C'	C'	C'	C'	C'	C'	C'	C'
This applies particularly in the case of a much-branched district.	C	C	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'
Before ventilating the fire area, all workings exposed to the hazards of fire gases or explosions of fire gases or fire-damp when the stopping is opened must be evacuated.	C	C	C	C	C'	C'	C'	C'	C'	C'	C'	C'
All electrical installations in these workings must be cut off from the power supply.	C	C	C	C	C	C	C'	C'	C'	C'	C'	C'
On safety grounds, it is advisable to open the return stopping first.	NRP	NRP	C	C	C'	C'	C'	C'	C'	C'	C'	C'
After the Rescue Team has withdrawn to less dangerous zones, the intake stopping should be opened.	NRP	NRP	C	C	C'	C'	C'	C'	C'	C'	C'	C'
When ventilating the fire area, the quantity of air and the content of inflammable gases in the air-current circulating through the fire area, and in the current into which it subsequently flows, should be checked.	C	C	C	C	C'	C'	C'	C'	C'	C'	C'	C'
The two air-currents should be mutually adjusted in such a manner as to ensure that no explosive mixture of gases is present over long distances after their junction.	C	C	C	C	C'	C'	C'	C'	C'	C'	C'	C'
Access to the fire area is prohibited until it has been ventilated.	C	C	C	C	C'	C'	C'	C'	C'	C'	C'	C'

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Netherlands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
V. OPENING OF FIRE AREAS CONTAINING EXPLOSIVE GAS MIXTURES Sealed-off districts may not be re-opened, either on one side or on two sides, if the presence of explosive gas mixtures behind the stoppings is established.	C	C	C	C	C'	C'	C'	C'	C'	C'	C'	C'
VI. OPENING OF FLOODED FIRE AREAS The composition of the air in fire areas flooded to extinguish the fire must be checked after draining.	C	C	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'
In workings with solid coal, allowance must be made for the increased hazard of spontaneous ignition after drainage. Where fire areas have been isolated by local flooding instead of by stoppings, the rules mentioned in section I to V should be observed, insofar as applicable, when opening a district.	C	C	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'
VII. REMANNING OF FIRE AREAS After ventilating a fire area, workings may not be manned until a Rescue Team has established that all workings are free of noxious gases.	C	C	C	C	C'	C'	C'	C'	C'	C'	C'	C'
If the fire area is merely being reduced in size, workings free of noxious gases may be manned only when the remainder of the fire-area has been sealed-off by permanent stoppings.	C	C	C	C	C'	C'	C'	C'	C'	C'	C'	C'

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Nether-lands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
III - Guidelines for the construction of advance fire stoppings from plaster (doc. 4928/63/2)												
In all cases where it is possible and advantageous, the erection of plaster stoppings to seal off fires and heatings is recommended.												
Is this process applied in practice as laid down in the guidelines contained in the report?	NRP	1) NRP	NRC	C	yes	yes	2) yes	2) yes	E	E	E	E
Is the application of this process prescribed by regulations?	NRP	NRP	NRC	C	no	no	no	no	no	no	E	E
Is this process applied in practice in a manner differing from the principles laid down?	NRP	NRP	yes	yes	no	no	no	no	no	no	E	E
Is the application of this modified process prescribed by regulations?	NRP	NRP	yes	yes	no	no	no	no	no	no	E	E
IV - Second report on specifications and test conditions relating to fire-resistant fluids used for power transmission (doc. 700/2/63)												
Part II - Specifications and test conditions (pp. 12 onwards)												
Article 1 - Conditions of authorisation												
1. Fire-resistant fluids for hydraulic power transmission and hydraulic control, before being used in mine workings, must be given a certificate of approval.	C	C	C	C	C'	C'	C'3) +E4)	C'3) E 4)	E	E	E	E
This certificate must indicate that the product has been subjected to the following tests:												
a) Laboratory tests (articles 3 - 7)												
aa) to determine criteria of flammability (article 3, p.15)	C	C	C	C	C'	C'	C'E	C'E	E	E	E	E

1) formulation of guidelines relating to fire stoppings and sealings; the section "fire stoppings made of bending materials" is equally applicable to advance fire stoppings.
2) the choice of means is, however, left to the mine-manager.
3) in the Charbonnages de France register, the Mines Safety Commission Recommendations have been taken into account.
4) the question of drawing up a new regulation is being examined by the competent authority.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Netherlands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
bb) to determine health criteria (article 4, p. 16)	C	C	C	C	C'	C'	C'E	C'E	E	E	E	E
cc) to determine technical criteria (article 5, p. 16)	C	C	C	C	C'	C'	C'E	C'E	E	E	E	E
b) Long-term tests during normal operations (article 8, p. 24)	C	C	C'	C'	C'	C'	C'E	C'E	E	E	E	E
2. These tests are carried out under an authorised body.	C	C	C	C	C'	C'	C'E	C'E	E	E	E	E
3. Authorisation for use underground should be dependent on presentation of the certificate mentioned in 1. above.	C	C	C	C	C'	C'	C'E	C'E	E	E	E	E
<u>Article 9 - Withdrawal of approval</u> At the request of the authorised body, the permitting authority may withdraw the approval for the fluid to be used in mine workings.	C	C	C	C	NRP	NRP	C'E	C'E	E	E	E	E
V - <u>Report on the electro-magnetic examination of winding rope (doc. nr. 8470/64/2).</u> Steps taken to develop electro-magnetic testing methods and results obtained.	C'2	C 2)	- 3)	- 3)	C'2)	C'2)	C'2) +4)	C'2) +4)	?	?	C'	C'
VI - <u>Report on the use of accelerometers to test winding installations doc. 3725/1/61, p. 9 (German text).</u> Tests with accelerometers should be continued on a large scale.	C'	C'	-2)	-2)	-	-	-	-	E	E	C'	C'
Use of accelerometers should be extended.	C'	1) C'E	-2)	-2)	-	-	-	-	E	E	C'	C'
VII - <u>Recommendation regarding the consulting of foreign experts in the case of rescue operations connected with major mining accidents (doc. 4364/61/3).</u>												

1) the formulation of rules regulating acceleration measurements in certain cases is being examined.
2) trials to improve electro-magnetic testing methods are underway.
3) measurements are taken in individual cases.
4) electro-magnetic testing of cables is required in certain exceptional cases in the General Mines regulations.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Netherlands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
In certain serious mining accidents advice requested by the leaders of the rescue operation from qualified foreign experts in mine-rescue matters. The heads of Mine Rescue Stations are provided for this purpose with a plan containing the most important addresses and information needed.	C'1)	C'1)	C'1)	C'1)	C'1)	C'1)	C'1)	C'1)	C'	C'	C'1)	C'1)
This plan should be constantly kept up-to-date.	C'1)	C'1)	C'1)	C'1)	C'1)	C'1)	C'1)	C'	C'	C'	C'1)	C'1)
VIII - <u>Report on firedamp-proof electrical equipment for nominal voltages above 1,100 volts (doc. 2400/64/1)</u> 1. What use has been made of the information contained in this report, and, in particular, to whom was it distributed? 2. The Working Party has noted that, in the Community countries, research into the development of low-oil or oil-less H.T. switchgear having the correct characteristics for use in gassy pits is being continued. What is the present position regarding this research and what data have been obtained to date?	Since, to all intents and purposes, only low-oil or oil-less switchgear is being used up to the present in new plant, no special use has been made of the information. It is for this very reason that no further research is being envisaged.		The information has been distributed to the department responsible for electrical equipment at the Technical Supervision Centre for mining equipment. No such research carried out in the Saar.		The report was published in "Annales des mines" and widely distributed. There are devices with satisfactory characteristics for use under specified conditions. – NRP – With regard to approval of these H.T. switchgear units.		NRP – Revision of the General regulations regarding use of electricity underground, especially in gassy and dusty pits, is in hand.		Nominal voltages over 1,100 volts forbidden.		NRP – Brought to the notice of all pits.	
3. The Working Party has noted that oil is being used in respect of relays, and that research would be needed to reduce or eliminate the use of oil. What research is being carried out to this end?	2)	2)	3)	3)	?	?	4)	NRP	4)	4)	3)	3)
4. This Report notes that switchgear specialists are trying to use less - or even no - oil with voltages above 1,100 volts and that, in particular, oil-less switchgear with separate poles, and low-oil switchgear, were being more and more widely used in most countries, at least for new plant.												

1) the main First-Aid Stations are in touch with the main Rescue Stations in the Community countries.
2) trials with oil-less relays are underway.
3) no research of this kind is being carried out.
4) see above.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Nether-lands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
These observations were deduced from practice during 1960 - 1962. What have been the trends since then?	1)	1)	2)	2)	3)	3)	4)	NRP	4)	4)	2)	2)

1) this trend continues.
2) not applicable.
3) within certain limits, these devices may also be used elsewhere after the promulgation of the new regulations.
4) cf. p. IX, 33.

II - HUMAN FACTORS

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Netherlands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
Recommendation on the fixing of climatic limits (the unabridged text is reproduced in doc. 3034/4/62)												
1.1 The basis is the American effective temperature (° eff basic scale).	C	C	C	C	C'	C'	A	E 6)	NRP	NRP	C	C
Air velocities above 3 metres/sec should be considered as only 3 metres/sec in determining the American effective temperature.	C 1)	C 1)	C	C	C'	C'	-	-	NRP	NRP	C	C
1.2 The temperature data must be given so as to make possible a comparison on the basis indicated under 1.1.	C	C	C	C	C'	C'	-	-	NRP	NRP	C	C
1.3 The climatic limits determined shall be maximum values.	C	C	C	C	-	-	-	-	NRP	NRP	C	C
More favourable climatic values for the workers shall remain unchanged.	C	C	C	C	-	-	-	-	NRP	NRP	-3)	- 3)
1.4 There will be further investigation into the effectiveness and accuracy of the various climatic indices.	?	?	-	-	-	-	-	-	NRP	NRP	-3)	- 3)
2. Determination of a maximum climatic value												
2.2 Work on location is forbidden in working places where the temperature exceeds 32° eff A (basic scale), excepting the cases named in 2.3 and 2.4.	C	C	C	C	-	-	2)	E 2)	NRP	NRP	C	C
2.3 An exception can be made to the ban on working on location in temperatures above 32° eff A (basic scale) if the competent authority has given permission and the workers in question have been medically examined. In this case the following conditions must also be fulfilled:	C 4)	C 4)	C	C	-	-	A	A	NRP	NRP	C	C
2.3.1 The responsible authority can only issue permission for a fixed period and for given working operations.	C	C	C	C	-	-	A	-	NRP	NRP	C	C
2.3.2 The work must be carried out under medical supervision.	C	C	C 5)	C 5)	-	-	-	-	NRP	NRP	C	C
Guidelines must be worked out, in collaboration with medical experts, covering the medical examination envisaged under 2.3.	C	C	-	-	-	-	-	-	NRP	NRP	C	C

1) 3,5 metres/sec.
2) working points where the temperature reaches 28°C are considered as particularly hot (without this being an absolute maximum value).
3) not applicable.
4) for mine rescue personnel.
5) medical supervision obligatory.
6) climatic values only have to be determined in certain very exceptional cases.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Nether-lands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
2.3.3 Work must not continue uninterrupted for more than one hour. A suitable break must then be arranged in a better "climate".	C	C	C	C	-	-	A	-	NRP	NRP	C	C
The duration of uninterrupted working time, as well as the duration and frequency of the breaks and the climatic range in which this break is spent, as also all other necessary provisions are to be laid down in writing by the competent authority together with the responsible doctor before the work begins.	C 1)	C 1)	C	C	-	-	A	-	NRP	NRP	C	C
2.3.4 Acclimatised persons must be chosen. Persons over 40 years of age should not be put to this work.	C	C	-	-	-	-	-	-	NRP	NRP	C	C
Persons under 21 and over 45 years of age must not be put to this work.	C	C	C 2)	C 2)	-	-	-	-	NRP	NRP	C	C
2.4 An exception can also be made to the ban on working on location in temperatures above 32° eff A (basic scale) if danger threatens or in special circumstances calling for immediate action.	C	C	C	C	C'	C'	C 3)	C 3)	NRP	NRP	C	C
In such case, however: 2.4.1 The competent authority and the responsible doctor must be immediately informed.	C	C	C	C	C'	C'	A	-	NRP	NRP	C	C
2.4.2 This work must be performed as soon as possible under the conditions listed in 2.3.1 to 2.3.4.	C	C	C	C	C'	C'	C'	C'	NRP	NRP	C	C
3. <u>Climatic range between 32° eff A and 28° eff A (basic scale)</u>							4)	4)				
3.1.1 Only persons shown by medical examination to be suitable can be employed in this climatic range.	A	A	C'	C'	-	-	C	C	NRP	NRP	C'	C'
The medical examination must pay particular attention to the heart and to blood circulation.	A	A	C'	C'	-	-	C	C	NRP	NRP	C'	C'
Persons continually employed in this climatic range must be examined medically at least once a year.	A	A	-	-	-	-	C	C	NRP	NRP	C'	C'
In addition, the following provisions apply:												

1) laid down generally in the mine rescue plans.
2) no provision made for excluding persons below 21 years of age from exceptional hot work.
3) ... ban on work on location in <u>excessively high</u> temperatures ...
4) range of climatic conditions above 28°C.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Netherlands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
3.1.2 As soon as a working-point reaches a temperature above 28° eff A (basic scale) the competent authority must be informed in writing.	A	A	C 1)	C 1)	-	-	A	A	NRP	NRP	C	C
3.1.3 The length of stay in the climatic range between 30° and 32° eff A (basic scale) is restricted to 5 hours,	A	A	C 2)	C 2)	-	-	A	-	NRP	NRP	C	C
and in the range between 28° and 30° eff A (basic scale) to 6 hours.	A	C	C	C	C'	C'	A	-	NRP	NRP	C	C
3.1.4 For work in a climatic range between 28° and 32° eff A (basic scale) a method of payment corresponding to these conditions must be applied to eliminate any overloading.	A	A 3)	A 3)	A 3)	-	-	C'	C'	NRP	NRP	C'	C'
3.1.5 The provisions quoted in 3.1.3 and 3.1.4 apply to all persons who, during one shift, have to work more than half the time of that shift in one of the climatic ranges mentioned above.	A	A	C	C	-	-	A	A	NRP	NRP	C'	C'

1) if 30° eff A (basic scale) is reached or exceeded, the Mines Inspectorate must be informed.
2) six hours.
3) must be arranged by tariff, outside the intervention of the Mines Inspectorate.

C - Regular report on the implementation of the Mines Safety and Health Commission's Recommendations published in the Fourth Report

HUMAN FACTORS

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Netherlands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
I. Recommendations on the psychological and sociological factors affecting safety (3rd report of the Mines Safety Commission, p. 425).												
1. Measures which will make it possible for workmen to recognise dangers and to carry out their work in such a way that these dangers are avoided												
1.1 Recognising dangers												
1.1.1 Before starting work in a district, a section of a working or a working-point and before any planned major change in the manpower deployment or in working conditions, it is important to check all the safety precautions to meet any dangers to be encountered.	C	C	C	C	C'	C'	C	C	C'	C'	C'	C'
1.1.2 During the work, regular reports on the following points must be prepared on the basis of the safety conditions which have to be observed under continuous supervision:												
a) changes in operating conditions					4)				C' 7)	C' 7)		
b) accidents or incidents					C	C			C'	C'		
c) dangerous situations encountered during work	C 2) + C' 1)	C+C'	C+C'	C+C'	5)	5)	C'	C'	C'	C'	C'	C'
The data brought together in these reports should be systematically assessed with a view to improving or adapting the safety precautions in force.	C 2) + C' 1)	C+C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'
1.1.3 After the work has been finished, the data assembled on the basis of daily experience should be used to prepare a report of experience	C' 3)	C'	C'	C'	6)	6)	C'	C)	8)	8)	C'	C'
which should at least include information regarding the winning methods used,	C' 3)	C'	C'	C'	6)	6)	C'	C'	C'	C'	C'	C'

1) laid down by the responsible authority for particular cases, otherwise generally included in the enterprise's manual.
2) laid down for accidents.
3) where new processes or materials are introduced.
4) no report is drawn up, verbal or written instructions given to the personnel concerned.
5) such situations are discussed at management or supervisor level, no report is drawn up.
6) no report is drawn up although account is taken of experience gained.
7) as regards the pattern of work and not actual operations as mentioned in the text.
8) not only when work is finished but in any case either weekly, monthly or annually.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Nether-lands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
the dangers which have arisen and the precautions taken to deal with them,.	C'[1]	C'	C	C	2)	2)	C'	C'	C'	C'	C'	C'
together with any accidents, incidents and dangerous situations which have occurred during the working operations.	C'[1]	C'	C	C	2)	2)	C'	C'	C'	C'	C'	C'
1.2 <u>Making known the dangers to all concerned</u>												
1.2.1 Before starting work in a district, a section of a working or a working-point or in the event of a major change in the operating conditions, it is advisable to arrange a discussion between representatives of the management, supervisory staff and members of the safety services as well as the workers concerned or their representatives, in order: - to inform each individual with regard to the work envisaged - to study in detail the work to be carried out - to settle upon the method of work	C'	C'	C'	C'	3)	3)	C'[4]	C'[4]	C'	C'	C'	C'
1.2.2 The workers concerned should be informed by the most appropriate means of the method of work chosen.	C	C	C	C	C'	C'	C	C	C'	C'	C'	C'
1.2.3 During the execution of the work, the management and the supervisory staff should refer to the regulations and instructions to be observed as often as necessary to counteract the effects of habit.	C	C	C	C	C'	C'	C	C	C'	C'	C'	C'
1.2.4 If it is considered necessary to issue new safety instructions, these should be brought regularly to the notice of every worker concerned.	C	C	C	C	C'	C'	C	C	C'[5]	C'[5]	C'	C'
1.2.5 Reports made by each of the workmen regarding dangerous situations which arise during the work should be brought to the notice of the management staff.	C'	C'	C	C	C'+C	C'+C	C'	C'	C'+C	C'+C	C	C

1) where new processes or materials are introduced.
2) no report is drawn up, although account is taken of experience gained.
3) this takes place at engineer or supervisor level, or even at Safety Committee level, but not at meetings where all the people mentioned are present.
4) workers' safety representatives may give their opinion and submit their observations in the form provided for in the labour legislation.
5) by means of service instructions issued by the management of the mine, or of service notes issues by departmental heads and supervisers.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Netherlands	
	1.1. 1968	1.1. 1970	**1.1. 1968**	1.1. 1970	**1.1. 1968**	1.1. 1970	**1.1. 1968**	1.1. 1970	**1.1. 1968**	1.1. 1970	**1.1. 1968**	1.1. 1970
1.3 <u>Instruction in the manner in which the work is to be carried out without danger</u>												
1.3.1 Every worker assigned to underground work must be able to show that he has:												
- a general training as an underground worker;	C	C	C	C	C' 3)	C' 5)	C'	C'	4)	4)	C	C
- a special training for the work to which he is to be assigned;	C 1)	C	C	C	C'	C'	C'	C'	4)	4)	C	C
- the necessary additional training to cover the special working conditions at the point where he will work.	C	C	C	C	C'	C'	C'	C'	4)	4)	C	C
1.3.2 Should there be a change in the work or in the working conditions, the necessary additional training must be provided.	C' 2)	C' 2)	C	C	C'	C'	C'	C'	C'	C'	C'	C'
1.3.3 Instruction in safety precautions is to be considered as an integral part of vocational training.	C	C	C	C	C'	C'	C'	C'	C'	C'	C'	C'
1.4 <u>Supervision to check that safety regulations are observed during work</u>												
1.4.1 During the work, the safety conditions must be subject to continual supervision.	C	C	C	C	C	C	C	C	C'	C'	C	C
1.4.2 The duty to see that safety regulations are observed, and the responsibilities resulting from this duty, fall upon the management and supervisory staff.	C	C	C	C	C	C	C	C	C	C	C	C
1.4.3 The supervision, which must be exercised with authority, should in its every-day action seek to improve the training and education of the workmen on the basis of daily experience, and should give rise to fines or penalties only in very serious or repeated cases of infringement.	C +C'	C'	C'	C'	C'+ 5)	C' 5)	C'	C'	C'	C'	C'	C'
2. <u>Training the management and supervisory staff in the matter of safety</u>												

1) laid down for particular cases, e.g. ventilation specialists, locomotive drivers and winch operators.
2) laid down by the responsible authorities for particular cases, otherwise generally included in the enterprises manual.
3) convention of the Joint National Mines Commission.
4) systematic training courses were provided up to 1963. After 1963, no new staff were engaged and therefore apprenticeship and training are only provided where new machinery and equipment is introduced.
5) concerns the last part of the sentence: "... and should give rise ...".

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Nether-lands	
	1.1. 1968	1.1. 1970	**1.1. 1968**	1.1. 1970	**1.1. 1968**	1.1. 1970	**1.1. 1968**	1.1. 1970	**1.1. 1968**	1.1. 1970	**1.1. 1968**	1.1. 1970
2.1 <u>General</u>												
2.1.1 Steps must be taken to ensure that the supervisory staff does not change posts frequently.	C'	C'	A 2)	A 2)	C'	C'	C'	C'	?	?	C'	C'
2.1.2 The vocational training should be adapted to the particular features of the staff member's task and his responsibilities, and in particular to the requirements of his place in the hierarchy of management or supervisory staff.	C' 1)	C'	C	C	3) C+C'	3) C+C'	C'	C'	C+C'	C+C'	C'	C'
2.1.3 The transition from one grade to another should be possible for a given person only after he has actually proved to have the required knowledge and skill.	1) C'	C'	C	C	C'	C'	C'	C'	4) C'	4) C'	C'	C'
2.2 <u>Guidelines for the vocational training of the management or supervisory staff</u>												
2.2.1 The management and supervisory staff must have an adequate knowledge of: - the safety regulations;	C	C	C	C	C'	C'	C	C	C'	C'	C	C
- the safety precautions to be taken;	C	C	C	C	C'	C'	C	C	C'	C'	C	C
- the available safety equipment and its use;	C	C	C	C	C'	C'	C	C	C'	C'	C	C
- the instructions in force for the different vocational groups whose work they are called upon to supervise, and the instructions for the exercise of activities at the working points for which they are responsible.	C	C	C	C	C'	C'	C	C	C'	C'	C	C
2.2.2 The management and supervisory staff must be able: - to point out in a suitable way to the workers under their orders the dangers associated with their work;	C'	C'	C	C	C'	C'	C	C	C'	C'	C'	C'
- to instruct these workers as to how best to carry out the work in order to avoid these dangers.	C'	C'	C	C	C'	C'	C'	C'	C'	C'	C'	C'

1) where certain supervisers are not recognised by the responsible authorities, the responsibility for carrying out this recommendation is left to the managing director of the mine.
2) cannot be laid down in the form of a regulation.
3) for the shotfirer.
4) by limited competition in the E.N.E.L. (Ente Nazionale per l'Energia Elettrica).

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Nether-lands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
2.2.3 The management and supervisory staff should be trained in how to issue instructions.	C'	C'	C'	C'	1) C'	1) C'	C'	C'	2) C'	2) C'	C'	C'
2.2.4 Special attention must be paid to the continual further training of all management and supervisory staff.	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'
2.2.5 The management and supervisory staff must both: - account for and report on the execution of their work, and	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'
- account for and report on all accidents and other notable incidents which have occurred during the working period at the points for which they are responsible.	C	C	C'	C'	C'	C'	C'	C'	C	C	C'	C'
2.2.6 The management and supervisory staff must be able: - to draw up accident reports correctly;	C	C	C'	C'	C' 3)	C' 3)	C'	C'	C'	C'	C'	C'
- to assess and use the data in these reports;	C'	C'	C'	C'	C' 3)	C' 3)	C'	C'	C'	C'	C'	C'
- to study and establish the causes of accidents;	C'	C'	C'	C'	C' 3)	C' 3)	C'	C'	C'	C'	C'	C'
- to work out means to avoid accidents;	C'	C'	C'	C'	C' 3)	C' 3)	C'	C'	C'	C'	C'	C'
- to receive the training necessary to this end.	C	C	C'	C'	C' 3)	C' 3)	C'	C'	C'	C'	C'	C'
2.3 <u>Staff responsible for training</u>												
2.3.1 The staff responsible for the training activities set out in paragraphs 1.3 and 2 must be numerous enough and must have available the necessary means and time to carry out their task properly.	C	C	C	C	C'	C'	C'	C'	4)	4)	C'	C'
2.4 <u>Drawing up of an accident report; training of staff responsible for filling in such reports</u>												

1) for the management staff. No systematic training in management for other grades.
2) this is not considered as a subject for training. Preference is given to constant supervision of the staff.
3) for the management staff. For supervision staff in certain cases only.
4) systematic training courses were given up to 1963. After 1963, no new staff were engaged and therefore apprenticeshop and training are only provided where new machinery and equipment is introduced.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Netherlands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
2.4.1 The accident report must, taking into account all the appropriate human and technical factors, give all necessary information and in particular:												
- the circumstances, the consequences of the accident, the causes,	C	C	C	C	C	C	C'	C'	C'	C'	C'	C'
- the precautions proposed to avoid similar accidents	C	C	C	C	C	C	C'	C'	C'	C'	C'	C'
2.4.2 Each of these items of information referred to in point 2.4.1 must be capable of formulation as an answer to a clear and precise question.	C	C	C	C	C	C	C'	C'	C'	C'	C'	C'
2.4.3 The breakdown and layout of the form used for accident reports must clearly show which questions have to be answered by each of the members of the staff contributing to the preparation of the reports.	C' 1)	C' 1)	C	C	C	C	C'	C'	C'	C'	C'	C'
2.4.4 There must be sufficient room on the form for supplementary remarks or sketches which may be provided by the person or persons concerned.	C' 1)	C' 1)	C	C	C'	C'	C'	C'	C'	C'	C'	C'
2.4.5 Each of the persons contributing to the preparation of the report must be informed with regard to:												
- the importance of each question,	C	C	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'
- the way to provide correct answers to the questions.	C	C	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'
2.4.6 Practical instruction should be provided to draw the attention of the employees concerned to the consequences of omissions, neglectful or unclear answers to the questions.	C'	C'	C'	C'	2)	2)	C'	C'	3)	3)	C'	C'
2.4.7 Systematic attention should be paid to ensure that the answers are complete, accurate and precise.	C	C	C'	C'	C	C	C'	C'	C'	C'	C'	C'
2.4.8 The accidents reports referred to in this chapter are to be drawn up for the sole purpose of accident prevention.	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'

1) the form used by the professional mining organisation does not comply entirely with this provision.
2) does not exist.
3) systematic training courses were given up to 1963. After 1963, no new staff were engaged and therefore apprenticeship and training are only provided when new machinery and equipment are introduced.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Nether-lands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
2.5 <u>Appointment and promotion of management or supervisory staff</u>												
2.5.1 Care should be taken to ensure that there is available an adequate number of management or supervisory staff possessed of the requisite skills both in the technical and safety fields.	C+C'	C+C'	C	C	C+C'	C+C'	C'	C'	C+C'	C+C'	C'	C'
2.5.2 The selection of this staff is the responsibility of the employer, who must at least inform the competent authority of the persons entrusted with supervision of working operations, together with the necessary data justifying the selection.	C	C	C	C	C	C	C 2)	C 2)	C+C' 3) A	C+C' 3) A	C	C
2.5.3 To ensure a selection which promises success, there should be laid down the minimum requirements for appointment to a post in one of these categories, either by direct appointment or by promotion, together with the certificates and other documents which are the necessary requisite for such an appointment.	C'	C'	C	C	1)	1)	C'	C'	4) C	4) C	C	C
2.5.4 The competent authority should be in a position to check the knowledge and skills of the management or supervisory staff - both from the human and technical points of view - should this authority consider it necessary, at least in the case of a major failure or of repeated failures in the performance of duties	C	C	C	C	6) C	5) C	A	A	A	A	C	C
3. <u>Usefulness of psycho-technical examinations</u>												
3.1 <u>On assignment</u>												
3.1.1 It is recommended that the application of a relatively simple psycho-technical examination upon assignment should be developed as far as possible, in order to:												
- determine the general intellectual level of the candidate;	5) A	5) C	C	C	7) C'	7) C'	C'	C'	8) C+C'	8) C+C'	C'	C'
- to exclude those candidates whose intellectual level lies below a pre-determined minimum.	C	C	C	C	7) C'	7) C'	C'	C'	8) C'	8) C'	C'	C'

1) does not exist in practice.
2) the managing director of the mine informs his chief engineer of the name of the departmental head in charge of technical matters.
3) as regards the reasons for the choice.
4) the law lays down a provision concerning the academic qualifications of directors and departmental heads.
5) psycho-technical examinations are required for certain duties only (winding-enginemen, locomotive drivers). Other enterprises have these types of examination for other duties.
6) for the shotfirers.
7) this ceased when recruitment was discontinued.
8) cf. 3) on previous page.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Nether-lands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
3.2 <u>Before the exercise of specific duties</u>												
3.2.1 In every instance, the workmen who are to be made responsible for the execution of particular working operations, - with which there is associated a particular responsibility in respect of collective safety or - which call for particular intellectual or personality characteristics should be subjected to a special psycho-technical examination to determine whether they have the capacities required for this activity.	1) C	1) C	2) C+E	2) C+E	3) C'	3) C'	C'	C'	E	E	C	C
3.2.2 The competent authority must, in co-operation with the representatives of the employers and employees, keep up to date the list of work for which those special examinations are to be prescribed and, to this end, should list the duties which have been shown by experience to call for such tests and for which such tests can in practice be carried out.	1) C	1) C	E	E	4)	4)	A	A	E	E	C'	C'
3.3 <u>Before any promotion of a worker to a supervisory post</u>												
3.3.1 Before the promotion of any workman to a supervisory post, a suitable psycho-technical examination must be carried out.	1) A	1) A	5) A	5) A	6) C	6) C	C'	C'	E	E	C'	C'
3.4 <u>Principles underlying the various psycho-technical examination</u>												
3.4.1 The psycho-technical examinations listed under 3.2 and 3.3 should, as far as possible, aid the vocational specialisation of the worker in question.	1) A	C	C	C	C'	C'	C'	C'	7)	7)	C'	C'

1) cf. 5) on previous page.
2) for winding-enginemen and locomotive drivers.
3) ceased when recruitment was discontinued.
4) does not exist.
5) eligibility for promotion within the supervisor grade is determined during the vocational training laid-down by the responsible authorities.
6) when there was in fact a psychological department.
7) systematic training courses were given up to 1963. After 1963, no new staff were engaged and therefore apprenticeship and training are only provided when new machinery and equipment are introduced.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Netherlands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
3.4.2 The management must lay down the criteria which have to be met by the candidate on assignment, or later, when directed to special tasks,	1) A	1) C'	E	E	C'	C'	C'	C'	C'	C'	C'	C'
and must seek the advice of psychologists when so doing.	1) A	1) C'	E	E	C'	C'	C'	C'	C'	C'	C'	C'
3.4.3 The psychologist's assessment will be valid only for a restricted period and must be compared with the assessments of the vocational behaviour of the person in question.	1) A	1) C'	E	E	2) C'	2) C'	C'	C'	E	E	C'	C'

(1) psycho-technical examinations are required for certain duties only (winding-enginemen, locomotive drivers). Other enterprises have these types of examination for other duties.
(2) when there was in fact a psychological department.

GENERAL REMARKS ON IMPLEMENTATION BY ITALY

It should be noted that, pursuant to Article 23 of the Mining Regulations in force, the subject referred to above has been included in the collective agreements.

The Italian coalmines, which as is well known, are only worked in the Sulcis (Sardinia) coalfield, have been for some time placed under the control of the "Ente Nazionale per l'Energia Elettrica (E.N.E.L.)", since their total production are intended for the Porto Vesme (Cagliari) thermal plants. The staff in these mines benefit from the guarantees given by the collective agreement applicable to workers in the electricity sector, which is among the most favourable collective agreements at present in force in Italy. In particular, this agreement excludes piecework and, consequently a negative answer should be given to the questionnaire as regards the application of the recommendation concerned or, in any case, the latter should be considered as not complying with the de facto situation.

For the sake of covering all contingencies, however, it was considered advisable to include the rather improbable possibility of new coalmines being opened, which are not directly linked with the production of electrical energy, and to answer the questionnaire on the basis of the collective agreement of 13 May 1967 which is applicable in the mining industry.

It should also be noted that, from page 49 onwards of the questionnaire concerned, the symbol "C" and other symbols used in the answer refer to clauses of the collective agreement mentioned above and not to standards codified in the form in legislation or regulations.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Netherlands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
II. Recommendations as to principles to be observed in view of the possible influence of payment at piece rates on safety in coalmines (4th report of the Mines Safety and Health Commission, Annex IV)									(cf. general remarks on previous page)			
1. Piecework arrangements	1)	1)							4)			
1.1 Minimum age; medical examinations												
1.1.1 To be assigned to piecework, a miner must												
- be not less than 18 years of age	C	C	C	C	C	C	NRP	NRP	C[5]	C[5]	C	C
- have undergone a medical examination to establish his fitness for such work.	C[2]	C[2]	C	C	C	C	C	C	C[5]	C[5]	C	C
1.1.2 Similar examinations must follow at regular intervals.	C'[2]	C'[2]	C[3]	C[3]	C	C	C	C	C[5]	C[5]	C	C
1.2 Make-up of piece rates												
1.2.1 Written particulars of the operations to be performed must be given to the men concerned, including such information as is needed to calculate the amount payable therefor.	C'[6]	C'[6]	C'	C'	C'	C'	C	C	C'	C'	C'	C'
1.2.2 In the interests of safety, the piecework arrangement employed must either												
- provide that operations of importance to safety shall be paid on a separate basis, or	-	-	-	-	C'	C'	-	-	C'	C'	C'	C'
- contain equivalent financial safeguards for the proper execution of such operations.	C'[6]	C'[6]	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'
1.2.3 In the event of its being found necessary to carry out safety operations not expressly provided for, this must not be allowed to affect the pay of the man or men concerned.	C'[6]	C'[6]	C'	C'	C'	C'	C	C	C	C	C	C

1) Questions relating to pay cannot be dealt with by the responsible authorities. Such questions are settled by means of collective agreements.
2) all workers are subjected to medical examinations when taken on and to similar examinations at regular intervals.
3) periodic X-ray examinations (every 15 months at most). Periodic clinical examination only where signs of pneumoconiosis are detected or on medical advice.
4) pursuant to Article 23 of the Mining Regulation in force, this question was the subject of collective agreements. Consequently, from page 2 onwards of the questionnaire, the symbols used refer to clauses of the collective agreement of 13 May 1967.
5) pursuant to the Mining Regulation and to the provisions relating to young workers.
6) settled by collective agreement.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Netherlands	
	1.1. 1968	1.1. 1970	**1.1. 1968**	1.1. 1970	**1.1. 1968**	1.1. 1970	**1.1. 1968**	1.1. 1970	**1.1. 1968**	1.1. 1970	**1.1. 1968**	1.1. 1970
1.3 <u>Fixing of norms and of rates payable therefor</u>												
1.3.1 The men must have the right to discuss the fixing of piecework norms and rates with the employer.	1) C'	1) C'	C'	C'	C'	C'	C	C	C	C	C	C
1.3.2 If agreement is not reached, the men or their representatives must have the right to start conciliation proceedings under 4 below.	1) C'	1) C'	C'	C'	C'	C'	C	C	3)	3)	C	C
1.4 <u>Forms of piecework</u>												
1.4.1 One-man piecework should preferably be permitted only where the operations concerned are not of a nature to allow of any other form of piecework.	2) A	2) A	C'	C'	?	?	C'	C'	C'	C'	C	C
1.5 <u>Determination of the norm</u>												
1.5.1 The norm must be determined in accordance with : the amount of time actually available during a normal shift;	1) C'	1) C'	C'	C'	C'	C'	C	C	C'	C'	C	C
the amount of work the men can fairly be expected to perform during this time, having regard to the working conditions;	1) C'	1) C'	C'	C'	C'	C'	C	C	E	E	C	C
the amount of time required to perform the operations properly.	1) C'	1) C'	C'	C'	C'	C'	C	C	C'	C'	C	C
1.6 <u>Calculation of the end wage</u>												
1.6.1 The basis and mode of calculation must be sufficiently simple for any worker to be able to work out for himself the sum due to him for a given period.	1) C'	1) C'	C'	C'	C'	C'	C	C	C'	C'	C'	C
1.7 <u>Performance in piecework</u>												
1.7.1 Regulations should be laid down requiring that periodic checks be carried out on the amounts of work performed for the purpose of determining the wages payable therefor,	1) C'	1) C'	C'	C'	C'	C'	C	C	C'	C'	C	C
and that the findings be duly notified to the men concerned.	1) C'	1) C'	C'	C'	C'	C'	C	C	C'	C'	C	C

1) settled by collective agreement.
2) for certain operations, one-man piecework is considered by both sides to the agreement as the most appropriate type of remuneration.
3) the collective agreement does not provide for conciliation procedures, although such procedure exists and the Ministry of Labour and Social Security acts as an arbitrator (whose decisions are not binding).

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Netherlands	
	1.1. 1968	1.1. 1970	**1.1. 1968**	1.1. 1970	**1.1. 1968**	1.1. 1970	**1.1. 1968**	1.1. 1970	**1.1. 1968**	1.1. 1970	**1.1. 1968**	1.1. 1970
1.7.2 Particulars must be supplied to the men of all additions and deductions affecting the amount of the end wage, together with details as to how these were calculated.	1) C'	1) C'	C'	C'	C'	C'	C	C	C'	C'	C	C
2. Changes in conditions at the work-place												
2.1 A piecework arrangement may be terminated or amended if the employer and the men are agreed that genuine difficulties warranting this course have been objectively found to exist.	1) C'	1) C'	C'	C'	C'	C'	C	C	C'	C'	C'	C'
Failing such agreement, the men must have the right to ask nevertheless that the arrangement be terminated or amended forthwith.	1) C'	1) C'	C'	C'	C'	C'	C	C	2) C	2) C	C	C
2.1.1 If the men cannot be paid at piece rates for so long as the difficulties persist, they must be paid a proper wage appropriate to their grade.	1) C'	1) C'	C'	C'	C'	C'	C	C	3) C	3) C	C	C
3. Managerial and supervisory staff												
3.1 In the interests of safety, extra supervision must be provided in workings where men are employed on piecework.	C'	C'	C'	C'	?	?	C'	C'	C'	C'	C'	C'
3.1.1 Since failure to carry out safety operations in good time can result in particular hazards, the supervisory personnel must give the men strict and relevant instructions to this effect, and check regularly to see that these are carried out.	C'	C'	C'	C'	C	C	C	C	C'	C'	C	C
3.2 Payment of managerial and supervisory staff												
3.2.1 Since managerial and supervisory staff are responsible not only for the organisation and smooth running of operations, but also												

1) settled by collective agreement.
2) provided for in agreements at provincial and enterprise level.
3) the collective agreement guarantees minimum pay and ancillary allowances.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Netherlands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
for the safety of the men engaged in them, they should as a rule be paid out on a basis independent of the ups and downs of production.	1) A	1) A	C'	C'	C	C	C	C	C	C	C'	C'
They may be granted production or output bonuses provided they have at the same time a sufficient financial incentive to devote the necessary attention to safety.	1) A	1) A	C'	C'	C'	C'	C	C	C	C	C'	C'
4. Settlement of disputes												
4.1 There should be a conciliation system for dealing with any disputes arising between management's and men's representatives with regard to piecework arrangements or their implementation.	2) C'	2) C'	C'	C'	C'	C'	C	C	3)	3)	C	C
4.1.1 The conciliation system should operate by means of a board on which employers and workers are equally represented, and which should approach disputes in the light of the present recommendations.	2) C'	2) C'	C'	C'	C'	C'	C	C	3)	3)	C	C
4.1.2 The fact that proceedings of this kind are pending must not affect the terms of employment of the men concerned,	2) C'	2) C'	C'	C'	C'	C'	C	C	C'	C'	C	C
who must continue to be entitled to a fair wage appropriate to their grade.	2) C'	2) C'	C'	C'	C'	C'	C	C	C	C	C	C

1) cannot be the subject of Mines Authority prescriptions. Settled according to area.
2) settled by collective agreement.
3) systematic training courses were given up to 1963. After 1963, no new staff were engaged and therefore apprenticeship and training are only provided when new machinery and equipment are introduced.

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TECHNICAL ASPECTS

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Netherlands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
V E N T I L A T I O N												
Practical conclusions on the application of the theory of stabilisation of ventilation (sixth report of the mines safety and health commission - Annex III)												
1. Supervision of ventilation The supervision of ventilation in a mining system requires an overall view, and should therefore be entrusted to a single man specially appointed, having at his disposal all the necessary means for carrying out his task.	C'		C		C'		C 1)		C		C	
2. Fundamental factors in ventilation Apart from a regular inspection and analysis of ventilation conditions in mines, ventilation officials require to have data on												
- the actual characteristics of the main and auxiliary ventilation fans,	C		C		C'		2)		C'		C	
- the order of magnitude of the aerodynamic effect of natural ventilation in summer and winter,	C + NRP		C		C'		C'		C'		C	
- the potentials of the intersections (at least the main ones).	C		C		E		3)		C'		C	
3. Additional representations of ventilation systems In order to obtain a precise picture of the overall structure of ventilation systems and to reveal possible instabilities, it would be advisable when necessary to have, in addition to the regulation diagrams, representations of other types, such as, for example :												
a) a representation of the whole of the mine workings in perspective (isometric or any other equivalent system);	C		C		E		5)		C'		C	
b) a diagram without any topographical information.	C' 4)		C'		C'+E		3)		C'		C	
4. Characteristics of ventilation The representations mentioned in conclusion No. 3 should make available all the data necessary for the understanding of analysis of ventilation, particularly:												
a) at the measuring points												
- the air quantities	C		C		NRC		C		C		C	
- the direction of the airflow	C		C		NRC		C		C		C	
- the methane content	C		C		NRC		2)		C		C	

1) in every colliery with over 500 workers the engineer responsible is also assisted by a supervisor who ensures application of the ventilation measures. In each coalfield an engineer has been specially entrusted with studying the application of the ventilation stabilisation theory adopted by the Mines safety and health commission.

2) applies to recent ventilators, but not to old ones.

3) these are being carried out.

4) carried out by means of network plans in ventilation calculations made by electronic computers.

5) applicable to some coalfields , but not all.

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Netherlands	
	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970	1.1. 1968	1.1. 1970
- the temperatures	C		C		NRC		2)		C		C	
- the pressures (at least at the principal intersections)	C		C		E		C'		E		C	
b) <u>in addition</u>												
- the lengths and average cross-sections of the roadway	C+C'		C		E		C'		C		C	
- the calculated resistances	C'		C		E		C'		E		C	
- the angles of inclination, particularly at the ends of the inclined and vertical section	C		C		E		C'		C'		C	
- the positions of the air doors and control doors, and of the barriers	C		C		E		C		C		C	
5. <u>Inspection of ventilation conditions</u>												
In each mine, there should be a systematic analysis of the ventilation system, at least once a year and after any major modification of the system, in order to detect any probable cases of instability under the normal operating conditions.	2) C + NRP		C		E		E 3)		C'		C	
In addition, cases of instability which may be caused by the introductions of additional aeromotive sources, or the changing or elimination of the existing aeromotive sources, should also be examined.	1) C + NRP		C'		E		E 3)		E		C	
6. <u>Informing the personnel</u>												
Taking into account the importance of ventilation for the whole of the underground workings, each responsible person should be informed of ventilation conditions within his own field.	C		C		E		C		C'		C	
Furthermore it is essential that separate meetings should be held once a year at least, as well as after any major modification in the ventilation system, at which the colliery ventilation engineer will explain the ventilation conditions obtaining at the pit, together with any modifications which have recently been made, in the presence of :												
a) the management officials, the technical departements, the chief of the rescue team and the officials responsible for ventilation;	C'		C		E		C'		E		C	
b) the local officials, each in respect of his own speciality	C'		C 4)		E		C		E		C	
On these occasions, attention should be drawn to districts where instabilities are already likely in normal conditions and, in particular cases of instability which make the occurrence of a fire likely.	C'		C'		E		C'		E		C	

1) headlines for the evaluation of pressure measurements are non being drafted.

2) not systematically recorded.

3) now being studied by the users.

4) this instruction is not usually given at separate meetings

Recommendations by the Commission	N.R./Wph.		Saar		Belgium		France		Italy		Nether-lands	
	1.1. 1968	1.1. 1970	**1.1. 1968**	1.1. 1970	**1.1. 1968**	1.1. 1970	**1.1. 1968**	1.1. 1970	**1.1. 1968**	1.1. 1970	**1.1. 1968**	1.1. 1970
7. <u>Exercises on plans</u> Once a year at least, the management or the competent mining authority should organise an exercise on plans covering measures to be taken in the event of an underground fire. This should be attended by the mine owner or his representative, the ventilation engineer and the competent officials responsible for the organisation of fire-fighting and rescue operations.	C' 1)		E		E		2)		E		C	
8. <u>Position of regulation doors</u> When doors are necessary for regulating ventilation they should be placed as near as possible to roadway junctions, taking into account other requirements, in order to facilitate access in smoky conditions.	A 3)		A 4)		E		5)		C'		C	
9. <u>Measures and equipment for slowing-down ventilation</u> In all collieries, devices for rapidly slowing-down ventilation in order to stabilise it shall be installed in all intake airways, subject to exceptions to be previously determined, after each roadway junction or branch, and as near as possible to it.	A 6)		C		E		7)		C'		C	
10. <u>Instructions to officials in the event of underground fire</u> Apart from the usual provisions regarding the obligation to attack any seat of a fire in order to extinguish it as soon as possible, and to inform the officials and management without delay, there should be instructions to officials laying down the other measures to be taken in the event of a mine fire in order to slow down ventilation so as to avoid an increase in the air supply to the seat of the fire.	A 8)		A 9)		E		10)		E		C	
11. <u>Instructions to management officials in the event of underground fire</u> No decision to modify the ventilation is to be taken by the management staff with a study being made of the consequences, by means of application of the theory of the stabilisation of ventilation, and with the help of plans and ventilation schemes which have previously been prepared in respect of all the possible causes of ventilation inversion whether these causes result from the fire or from the structure of the mine (ventilation by multiple fans etc.).	C'		A 9)		E		C' 11)		C		C	

1) will be regulated by the fire-fighting plan.

2) these will be organised after implementation of the Budryk plan, but the ventilation officials and the rescue centres already contact each other from time to time.

3) owing to the different local conditions a uniform regulation would be unsuitable.

4) the decision is to be taken by the head of the fire-fighting unit.

5) as soon as possible, but not automatically.

6) experience has shown that it is more convenient to have a central store of materials for constructing regulation doors.

7) now being studied by the users.

8) the ventilation must be not modified except on the express order of the officials in charge.

9) the decision is to be taken by the leader of the fire-fighting unit.

10) not supervisors level but the chiefs of rescue teams and the rescue centres.

11) to be specified after implementation of the Budryk plan.

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