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Szczyrk Conference Papers -- Part I. Coal: Issues for the Eighties (Proceedings of Meeting: November 6-9, 1979)

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SZCZYRK CONFERENCE PAPERS--PART I
COAL: ISSUES FOR THE EIGHTIES

Proceedings of Meeting
November 6-9, 1979

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PREFACE

This volume is the first of two Collaborative Papers which contain the technical papers presented at an IIASA Seminar under the generic title 'Coal: Issues for the Eighties' which was held in Szczyrk, Poland in November 1979. The seminar was jointly organized by IIASA and the Polish institutes collaborating in this study. The papers are here reproduced for the convenience of those attending the seminar and for reference by those involved in this continuing industry study. The second volume contains those papers concerning the environmental issues, CP-80-24.

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COAL: ISSUES FOR THE EIGHTIES

Jan Stachowicz, Rolfe Tomlinson

GENERAL INTRODUCTION

The papers set out in these two Collaborative Papers were presented at an IIASA Seminar for Industry Studies, namely, "Coal: Issues for the Eighties", which was held in Szczyrk, Poland, in November 1979. The seminar was, on this occasion, jointly organized by IIASA and the Polish institutes collaborating in this study with IIASA, i.e., Institute for Organization and Management Problems of the Polish Academy of Sciences, Bytom and the Computer Center of the Mining Industry in Katowice.

It may be worth saying something about the general concept lying behind the IIASA Industry Studies, particularly "Coal: Issues for the Eighties." The purpose of these Industry Studies was to bring together specialists, both managers and analysts, from different countries to identify the main issues which the industry faces over the next ten years, to identify the way and approach in which systems analysis can assist in major policy and decisions and to engage in a collaborate program of information exchange and research.

The coal mining industry is particularly appropriate for such a comprehensive study because it is a critical energy industry faced with expectations of greatly increased demand before the end of the century, and with the need to make major investment to decisions at a time when existing capacity is not fully utilized. Markets in the future may be very differently located from the present, and the transport situation needs to be reassessed. The future use of the product is uncertain--it might be needed for electricity generation, gasification, liquefaction or other end uses. The production technology is undergoing change, and the impact of the computer is only just beginning. At the same time, concern about pollution of earth, water and air is growing--leading to major regulatory controls of various kinds. It is an industry in transition, and most of these critical issues are appropriate subjects for systems analysis.

Moreover, the coal mining industry has developed over a long period of time under a variety of conditions, and has a good record of international collaboration. This gives a good basis for comparative studies that can be used to provide results of general applicability. Two recent meetings, the 10th World Mining Congress in Istanbul in 1977 and the UNO Coal Seminar in Katowice, Poland in 1979, have confirmed the potential return from developing international scientific cooperation in the scope of coal mining. Systems analysis has, as we have said, a major part to play in tackling the problems of coal mining development. "Coal: Issues for the Eighties" is intended to contribute towards these, and the Szczyrk seminar was a step in this process:

The main purposes of the seminar were:

- to present papers on those topics identified at the Inaugural Task Force meeting held at IIASA in March 1979;
- to facilitate the exchange of experience, results, methods, etc.;
- to establish a plan for the future.

The seminar was attended by participants from Austria, CSSR, FRG, Hungary, Italy, United Kingdom, USSR, USA and Poland. Eighteen presentations were made by participants from six countries and three by IIASA participants. Most of the presentations concentrated on the main seminar topics, i.e.,

- management, organization and the computer;
- planning for planning;
- environmental issues.

Some of the presentations, however, were devoted to more general problems in the coal mining industry. Four papers were wholly devoted to the question of "planning for planning" and two presentations covered this topic in part. Taken together they provided an overview of OR and systems applications in mine planning as well as presenting a good deal of useful experiences on the use of computers in support for planning in the coal mining industry.

The next group of papers was concerned with "management, organization, and computers" in coal mining. The presentations and discussions on this subject focused on two main aspects:

- general problems of organization and management in the coal mining industry, and
- the exchange of results and experience on the use of computers for management.

Three papers dealt entirely with this area and two partially.

The third group of papers dealt with "environmental issues" such as management of air pollution with regard to effects from coal use, groundwater depletion and other effects from coal extraction, and other effects from coal utilization technologies and comprehensive coal/environment planning approaches in selected countries.

All the papers presented here are as given at the seminar, without editing. The purpose is to make them readily available to those who took part in the meeting and to their colleagues. Many will appear in a modified form in the literature. A report on the conference as a whole is available as an IIASA working paper WP-80-140.

The seminar was successful in two respects. Firstly, it had provided the opportunity for the exchange of experience and an insight into different methodological approaches to problems, that could not have been obtained in any other way. No other meeting currently catered for this need. Secondly, it had made it possible to identify the direction that future collaborative studies might take. Such studies need not in fact be narrowly related to the coal industry but could concern, for example, the role of coal mining in global industrial development. The work was also relevant to many other IIASA studies, e.g., related to management under uncertainty, computer/management interactions, innovation, etc.

We would like to take this opportunity of thanking the Institute for Organization and Management Problems of the Polish Academy of Sciences in Bytom and the Computer Center of the Mining Industry for their efforts to ensure good work conditions for this meeting and for their hospitality. It was another example of successful international cooperation.

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WORLD COAL PROSPECTS: DRAFT REPORT
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

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TCD/NRET/AC.12/12
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on World Coal Prospects

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15 to 23 October 1979

INTRODUCTION

1. The United Nations Symposium on World Coal Prospects was attended by about 170 experts from developed and developing countries [1/], as well as international organizations, in order to exchange experiences relating to the principal problems connected with the present and the future role of coal in the world energy economy . The deliberations took place in the light of the need to strengthen international co-operation , with special attention being given to the needs of developing countries .

2. The basic documents presented at the Symposium were as follows :

- the official address on behalf of the Secretary-General of the United Nations ,
- the official address on behalf of the Polish People's Republic ,
- two keynote reports , one on the developed countries , and the other on the developing countries ,
- eight general reports covering the most essential coal problems , specifically : reserves and resources , production , utilization , transport , international trade , institutional aspects , labour and training and research and development .

3. A considerable contribution to the deliberations of the Symposium was made by the numerous country reports , expert papers , and statements made by the participants during the discussions.

4. In all the reports many detailed conclusions , formulated in the light of the Symposium's purpose have been prepared.

1/ In addition , 200 Polish experts participated in the Symposium.

This chapter of the Report of the Symposium will only highlight some of the main conclusions and recommendations of the participants .

5. The Symposium took place at a crucial moment in the world energy situation : for the second time in this decade the energy market was characterized by serious disturbances that had resulted from a rapid price increase in the basic source of primary energy , petroleum . Without going into a deeper examination of this situation,it had to be emphasized that the energy problem was directly connected with increasingly acute pressures on oil supplies as a result of depleting reserves and slower growth of new discoveries in comparison with the rate of oil extraction .

6. Because oil had the largest share of world energy consumption , a common opinion prevailed among experts on the necessity of simultaneous development of all available energy forms . At the same time serious efforts had to be made to save energy. Sufficient energy supplies were an indispensable prerequisite for economic development , and consequently , for improvement of the living standards of people around the globe , particularly in poorer countries .

7. During the Symposium many speakers referred to the findings of the Tenth World Energy Conference held in Istanbul in 1977 . The results of the Conference indicated that on the basis of coal equivalent coal comprises 81 per cent of fossil fuel resources , oil 17 per cent , and gas 2 per cent , while in 1977 production the shares of these fuels were : coal 33 per cent , oil 46 per cent and gas 21 per cent . These figures showed that there was on the one hand a disproportion between petroleum resources and production, and on the other an enormous potential to increase coal production .

8. Although nuclear energy had played an increasingly important role in recent years , on a worldwide basis the implementation of programmes regarding the develo-pment of nuclear energy had been significantly delayed owing to technical , economical , and environmental con-siderations.

9. Even with the most ambitious efforts to develop non-conventional forms of energy such as solar , geothermal, wind and tidal , they could offer only a marginal contri-bution to the world energy market in the foreseeable future.

10. In this situation , there was emerging a consensus that was also manifested in the course of the Symposium , that coal was the single primary energy form capable of bridging the anticipated gap in world energy supplies in the decades to come .

11. Coal was a versatile fuel as oil and gas . It could be used for electricity and heat generation , in metallur-gical processes , and in the chemical industry. Moreover, an outstanding advantage of coal was its suitability for conversion into liquid and gaseous fuels .

12. However , it had to be admitted that coal had a number of disadvantages as well , which in times of abun-dant oil and gas supplies caused coal and its products to be less attractive . Among these disadvantages were high production costs; more difficult handling in transporta-tion and utilization ; demanding working conditions , particularly in underground operations ; and the impact of mining and utilization processes on the environment.

13. All these disadvantages could be and indeed currently were being eliminated through the application of science and technology to industrial practice .

I RESERVES AND RESOURCES

14. According to the World Energy Conference , world coal resources amounted to 10.125 billion tons of coal equivalent /tce/ . With coal production at a level of 2.7 billion tce in 1977 , these resources would have sufficed for several thousand years. However , among these resources only 636 billion tce , that is 6.3 per cent, could be characterized as suitable for extraction at the present level of costs, technology and prices . A similar , but simplified , calculation would show that reserves were enough for 236 years , but assuming an exponential annual rate of growth of production of 3 per cent , those reserves would be exhausted after merely 71 years . However , the magnitude of the world's coal reserves required examination from a dynamic point of view which would include consideration of changing costs of production , changing technology and changes in the prices of alternative energy sources . For example , the recent sizeable increase in oil prices may have led to an increase in world coal reserves .

15. Nevertheless , the above considerations point out that in spite of virtually enormous coal reserves , sufficient for at least several generations , extraction of coal should be conducted so as to guarantee optimum conservation of coal reserves and maximum recovery of coal from deposits .

16. Coal deposits occurred more numerously and commonly throughout the world than those of oil and gas. However, at the same time reserves were located in moderate and subarctic zones of the northern hemisphere . The major part of reserves totalling 578 billion tce , or 91 per cent , were in regions with the highest coal production /Europe , USSR , China , North America , Australia , and the Republic of South Africa/.

The other countries in Asia , Africa and Latin America possessed the remaining 58 billion tce , or 9 per cent. This implied that developing countries had a relatively small base of coal reserves .

17. It was still not clear whether such an uneven distribution of coal reserves , being disadvantageous to developing countries , stemmed from geological reasons or whether - as some geologists assert - it was the result of the lack of exploration for coal deposits in Latin America , Africa and Southeast Asia , where unknown reserves might lie. It was already apparent, however , that a systematic and, if possible , intensified effort to assess the financial and other requirements of developing countries in coal exploration as initiated by the United Nations as a result of General Assembly Resolution 33/194 deserved the support of interested international , regional and bilateral assistance sources . In this connection , the application of new techniques in coal exploration was particularly emphasized .

18. It is noteworthy that within both resources and reserves three quarters fell to hard coal and the rest to brown coal and lignite . About a quarter of overall reserves was coking coals which had the potential to meet metallurgical demand.

19. The World Energy Conference was only one of a number of institutions dealing with the estimation of the magnitude of world energy reserves , hence there were different estimates - quite frequently widely divergent - on resources and reserves of various categories. Therefore ,the conclusions drawn depended on the degree of accuracy of estimation of the undiscovered amount of world coal resources and reserves.Particularly important was the size of reserves. However , it seemed certain that as increasing exploration and development of mining technologies ensured improved recovery of coal , the real amount of reserves would be larger than the one assessed today .

Obviously , the situation concerning the scope of available reserves and the level of possible production would vary considerably from country to country .

II PRODUCTION

20. The World Energy Conference had revised its assessment of world energy demands by 2020 in the light of the energy problems of 1973/74 . According to the Conference , the demand for coal in the year 2000 would be in the range of 5.8 billion tce , more than twice the 2.7 billion tce of coal produced in 1977 , and in 2020 the demand would have risen to 8.7 billion tce, more than a thereefold increase .

21. Consequently , the size of coal reserves was not a constraint on the expected growth of production .

22. In order to meet the growing demands for coal , it was necessary to begin prompt execution of investments for the development of new mining regions , the construction of new mines and the reconstruction of operative mines. This also entailed creating the accompanying infrastructure. Mining investments were highly capital-inteneive .There were opinions expressed that even in the developed market economy countries financial support from national budgets would be imperative:private capital would prove incapable of financing such expansion . In this respect a specially difficult situation prevailed in those developing countries that were going to create or extend their coal industry . These countries might be unable to raise greater amounts from internal sources . Instead , assistance from developed countries and from international financial organizations would appear to be indispensable .

23. Mining investments displayed a long time before planned production objectives could be achieved . Nowadays , the lead

time for a big colliery was from four to five years from the start of construction to initial coal output , and another four to five years to reach final production levels.

24. The large amount of capital required , and the long lead times to production and the low level of coal prices - - frequently less competitive than prices of alternative fuels , had induced some countries and mining companies not to undertake financial risks for coal investments . Such an attitude was unjustified in view of the fact that the realization of coal investments launched today would not be brought to full fruition until 1990. In the meantime ,due to the continuous depletion of oil and gas ,the prices of these fuels were bound to rise and to face difficulties in supply.

25. Hesitation in decision-making on coal did not refer to all countries as was evidenced by the uninterrupted , though relatively slow, growth of world coal production . However , any attitude of uncertainty in view of rapidly growing future demands could lead to further difficulties in the energy situation , particularly in developing countries .

26. A partial solution of the problems connected with investments lay in the development of opencast mining wherever feasible . Opencast mining investments were less capital-intensive and had shorter lead times . Moreover , opencast mines offered lower production costs . However , there were significant factors limiting opencast mining development, most importantly , the availability of appropriate reserves and the regulations on environmental protection.

27. It was to be emphasized that geological and mining conditions associated with coal mining , particularly in underground operations , were becoming increasingly difficult due to the growing depth of extraction. These difficulties mainly consisted in the build-up of rock pressures , in intensified methane emissions , and in rising temperatures of the mining environment.

28. Principally , the practised methods of underground coal extraction in the world could be divided into room-and-pillar and longwall mining . In each a number of variants could be distinguished . The technique of the room-and-pillar method was simpler than longwalling ,but it entailed considerable losses of coal . With growing depths , the abandoned seam pillars became dangerous because of the , growing rock pressures . These problems intensified beginning at a depth of about 300 m , until at depths of more than 600 m room-and-pillar was virtually impossible. On the other hand , longwall methods avoided such problems and made possible high production from a single face . In European conditions room-and-pillar methods played only a marginal role .

29. Both room-and-pillar and longwall mining could be run without mechanization , resulting in a large number of unskilled personnel , with low production and productivity ;partial or full mechanization yield high production and productivity from one face but , at the same time , require highly skilled crews. Developing countries would have to give serious consideration to what method to use in deep mining for coal in the light of their particular situation in each case.

30. Conventional coal extraction methods involved a number of technical and environmental barriers to further progress, which moved some countries to undertake trials on unconventional methods . One of the most promising appeared to be underground gasification. This technique could also be applied to extract fuels from deposits unsuitable for mining by conventional methods. Hence , underground gasification could contribute to the enlargement of recoverable coal reserves .

III UTILIZATION

31. If coal was to be competitive and attractive as compared to other fuels , efforts were needed not only in improving coal production but also coal utilization . Run-of-mine coal usually required processing before final utilization . Customers were setting rigid requirements on quality parameters , such as low contents of ash , sulphur , and humidity; uniform grain sizes ; high calorific value ; and in some cases - specific coking properties . Therefore , the requirements were directed towards obtaining market coal which in the utilization process would guarantee a high degree of energy efficiency and minimize impact on the environment.

32. In the coming decades increasing demand for coking coal needed in steel production would be felt. There was also a growing demand for coal in electricity generation . In order to utilize waste heat from electric power stations ,more and more plants were combining production of electricity and heat , the latter being supplied centrally to nearby industrial plants , towns and housing estates . Technologies were also under development to utilize low-calorie solid fuels or coals with high sulphur content .
One promising method was fluidized-bed combustion. Such technologies were of particular interest to developing countries where low-grade coal deposits could be made usable in this way . An additional advantage was the possibility of developing coal deposits on a small scale without the usual penalties resulting from economics of scale. It was pointed out in this regard that some developing countries were ready to embark on significant coal development plans.Similarly , emphasis was placed on the potential of coal utilization in rural areas to arrest the adverse consequences of deforestation resulting from excessive use of wood .

33. From the 1980s on , technologies of coal liquefaction and coal gasification would find increasing commercial application . Coal liquefaction could produce practically all the products that were derived from oil. Coal gasification would be aimed at producing synthesis gas mainly for the chemical industry . Further processing of synthesis gas to increase its methane content would allow production of high-calorie Substitute Natural Gas /SNG/.

IV TRANSPORT

34. Production growth was closely connected with the development problems of a transport infrastructure. These were increasingly difficult , as new coal regions were frequently located at remote distances from the centres where coal or coal-derived energy was used. Such situations might be encountered in countries with vast territories as well as the smaller states, and were a notable feature of many developing countries wishing to extend their coal mining .

35. In rail transport there was a trend to carry coal by unit trains commuting between loading stations at mines and major consumors .

36. Quite recently some slurry pipelines for transportation of coal at longer distances have begun operation . That idea of hydrotransport had gained more and more supporters as could be inferred from the number of coal-slurry pipelines planned or under construction .

37. Another solution of the transport problem was the unified mining-and-power complexes. These were located in the proximity to brown coal deposits in particular . Electric power produced in such complexes was delivered to consumers by

high-tension transmission lines , frequently over long distances. In the future mining - chemical complexes would undoubtedly be erected to produce liquid and gaseous conversion products.

38. Countries with a usable river network could certainly create anew or expand existing river transportation systems since this is a very unexpensive means of moving coal.

39. In the field of ocean shipments ,a number of countries were constructing or developing port facilities for handling coal ships with over 100.000 ton capacity .

V INTERNATIONAL TRADE

40. World coal trade in 1977 was 226 million tons , about 9 per cent of the total hard coal production. This was considerably lower than in the case of oil, where 60 per cent of oil production was moved internationally .

41. According to the World Energy Conference , in the year 2000 coal trade would increase to 580 million tce. This would mean a higher rate of growth than in the case of the overall expected coal production .

42. As was usual with forecasts , the estimates of exports from various institutions were widely divergent : some presumed that in 2000 coal exports potential might even reach 1 billion tons .

43. The actual volume of coal in international trade would depend on the one hand upon the size of future demands for specific types of coal , and on the other upon the capabilities of meeting those demands by producers .

44. Also in this regard there were widely differing opinions. Therefore ,one of the more important topics in international collaboration should concentrate on monitoring the current situation in world coal trade ,so as to take possible corrective measures by all those concerned .

45. Eighty per cent of world coal trade was made up of coking coal . In spite of the envisaged drop of its share to the advantage of steam coal , the absolute tonnage of coking coal would continue to increase in the light of the anticipated expansion of world steel production .

46. Limitations being imposed on the use of oil for electricity generation , and the well-known development problems of nuclear energy,had created very favourable circumstances for steam coal.

47. In coming years , exporters would remain largely the same, as would the countries that presently played the principal role in this trade , although the relative shares from individual countries could vary . The number of exporters would be enlarged at most by a few new countries .

48. In general , the number of developing countries with the potential for coal exports would not be large , due to their own intensively growing energy demands that would have to be met primarily from internal resources . However , many developing countries were expected to increase their electricity consumption by higher annual rates than in other countries and therefore they could be regarded as potential steam coal importers where no indigenous coal or other energy resources were available . In any case , development of local resources would require long-term planning with consequent investments for the coal mining operations and associated infrastructure . This policy would help make it possible to lessen dependence on imported oil supplies .

49. There were a growing number of developing countries that already had got or wanted to establish their own steel industr and accordingly there would be an increasing number of importers of metallurgical coal.

50. It was expected that the countries of Western Europe and East Asia would continue to be the major importers of steam coal.

51. In the context of the predicted growth of international trade in coal , again should be emphasized that there was a necessity of expanding the existing transport infrastructure .

52. In discussing international trade , it was important not to overlook the vital problems of trade in mining machines and equipment and , moreover , of transfer of mining know-how in the fields of prospecting and exploration ,planning the expansion of coal industries and design and construction of mines as well as the extraction and processing of coal.

53. Developing countries needed comprehensive assistance in those fields. But it was to be emphasized that developed countries from East and West had a significant technical and scientific potential which could and should be increasingly applied for the benefit of developing countries .

VI INSTITUTIONAL ASPECTS

54. In countries where mining was conducted , the legal situation of mining was varied . The legal beses of mining were strongly founded in developed countries , whereby the nature of appropriate documents depended to a large extent on the socio-economic system prevailing in the given country.

55. In countries with centrally-planned economies mineral resources belonged to the State. All geological and mining activities were carried out by State-owned institutions and were based on detailed legal principles codified in the mining law , and in some countries also in a seperate geological law. Mining as a branch of industry was set in the framework of min stries which were the top level of what was usually an organizational structure having three levels.

The middle level is composed of divisions responsible for various industrial and commercial concerns , as well as research and development . The divisions in turn supervised a number of enterprises which occupied the lowest level.

56.In countries with a market economy, minerals could be privately owned . Therefore , their extraction could also be conducted and managed by private companies of the country, by foreign companies , and by mixed enterprises . The government wielded a more or less rigid control on the basis of specific regulations . This control was a two tier in the case of federal countries because of seperate jurisdiction at the central and provincial levels . In a number of market economy countries a mining law was also the repository of the main legal code . It was noted in this connection , however, that control over coal reserves could become particularly important if market forces were not permitted to function properly . Since in some countries a significant proportion of reserves was increasingly being controlled by transnational energy corporations, further study was called for on possible consequences.

57. Thus , developing countries intending to establish the indispensable institutional and legal framework for their own mining had for that purpose a fair range of examples from developed countries . The adoption of a proper system depended on numerous conditions prevailing in a given country .

58. It was obvious that the multifarious features of particular countries would always have a bearing on the differentiation of geological and mining regulations in relation to local needs.
However ,it was worth emphasizing that there was now emerging the necssity of having an internationally accepted code in order to facilitate intensified international contacts, particularly in the field of trade . From the more outstanding

matters calling for standardization on an international scale , mention could be made of the following : classification of coal resources and reserves to define more accurately their size according to types of coal ; classification of solid fuels for purposes of trade and utilization ; clasification systems regarding particular mining hazards, among other things , in order to unify the principles of admittance of mining machinery into operation ; standards for protecting the environment from the effects of coal mining operations and the utilization of coal and its products.

VII LABOUR AND TRAINING

59. In coal-producing countries the number of people employed in coal mining is usually less than one per cent of the total work force . This fact appeared to testify that there should be no major obstacles in recruiting labour to work in collieries ,.

60. In connection with the constant technical and organizational progress , productivity would be improving , although at the same time the geological and mining conditions would be deteriorating. Therefore , it was to be expected that the rate of productivity growth would not exceed very much the rate of production . On the basis of forecasts made by the World Energy Conference on coal production , the International Labour Organization estimated that the rate of productivity would exceed the rate of production by between 1 and 3 per cen Consequently , the ILO predicted that by the year 2000, as compared with 1977 , with a 2,3 -fold production increase the workforce would have increased 1,8 times , while in 2020 with a 3,5 -fold higher production the work force would have increased by 2.5 times . In this way ,with a probable employment of 4.7 million people in coal mining in 1977, this was likely to rise to 8.4 million in 2000 , and to 11.6 million in 2020.

61. As could be seen , this predicted increase in the number of employees would not be easy to arrive at , This appeared to confirm the assertion of many experts that one of the most challenging problems in the achievement of the predicted increase in coal production would be - apart from the availability of capital for expanding production capacity - the recruitment of labour . In developed countries the problem would concern recruitment of people in general , and in developing countries , the recruitment of skilled people .

62. In order to encourage people to work in coal mining , the miner's trade had to be made more attractive . The work of a miner had to become easier and more productive . The working environment had to be improved through guarding the miners against natural hazards . The miners and their families should also enjoy proper living conditions .

63. The importance of familiarity with basic safety regulations, and the growing demands with regard to skills, required a suitable system of training and education for people already working or intending to work in mining . Such systems existed in all developed countries , and in some developing countries .

64. So long as developing countries were not in a position to prepare skilled personnel for mining domestically , the developed countries should offer them the necessary assistance. The developing countries themselves , however , have achieved significant levels of training in other energy industries , and training programmes in coal exploration , development and utilization should be given some priority in view of the special energy problems of most of the developing countries. International assistance organizations should increase their role in this regard .

VIII RESEARCH AND DEVELOPMENT

65. An indispensable factor in reducing the technical and economic difficulties in mining was the active development of research and development . This was aimed at providing increased productivity, improved safety , protection of environment , and more favourable economics.

66. At presents , the principal directions of R + D in coal mining were :

- further development of extraction technologies in underground and opencast operations to safeguard higher output and safety,
- improvement of coal preparation technologies in compliance with the requirements of coal utilization ,
- solution of problems connected with transportation of large coal tonnages over considerable distances ,
- coal conversion into liquid , gaseous , and solid fuels and chemicals ,
- control of coal extraction and utilization processes to minimize the impact on the environment .

67. In developing countries increasing R + D activities were also being undertaken to meet the specific needs of particular countries . However , due to the increasingly complex nature of coal development , it was today unthinkable to conduct effective R + D without international co-operation embracing all the countries concerned .

IX INTERNATIONAL CO-OPERATION

68. The present and future energy problems had worldwide dimensions and , therefore, had to be solved on an international scale .

69. Issues concerning coal as one of the basic primary energy forms were subjects of interest at numerous centres in the world. An approach consisting in tackling the essential matters from various angles was extremenly useful in the light of safeguarding sufficient energy supplies and , consequently , of minimizing tensions not only in the world energy situation, but in the world at large .

70. There were countries with developed mining potentials and countries with less favourable capacities . All international co-operation should take into account endeavours aimed at the reduction of gaps in technical levels between coal industries of various countries . A significant role in this co--operation could be accorded to R + D .

71. In international co-operation concerning coal , outstanding functions were to be performed by the United Nations and the various organizations associated with it. From among them , first of all was to be mentioned the UN Economic and Social Council with its Centre for Natural Resources ,Energy and Transport, Department of Technical Co-operation for Development, under whose auspices this Symposium had taken place . The organ which was completely dedicated to carrying out comprehensive co-operation in coal problems, was the Coal Committee of the UN Economic CCommission for Europe. The Committee's activities were discharged with the assistance of six permanent groups of experts who focused their attention on such vital issues as: perspectives on the role of coal , extraction methods, transportation , preparation , utilization , economics , environmental protection and many others. Coal was also referred to

in the activities of the International Labour Organization through its Committee of Coal Mines , UNESCO , UNEP , UNIDO , UNCTAD , UNITAR , and others.

72. In concluding ,the results of this UN Symposium on World Coal Prospects should become guidelines for strengthoning and widening the activities of the abovementioned organizations as well as others involved the field of coal.

SOME PROBLEMS OF MANAGEMENT AND PRODUCTION ENGINEERING IN THE COAL INDUSTRY OF THE USSR

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The coal industry of the USSR is characterized by high rates of development - in 1978 the total run-of-mine coal production amounted to 723.6 million tons (664.4 million tons of salable coal), an increase of 100 million tons, or by 16%. as compared to 1970. The development of the coal industry is accompanied by coal production concentration - the number of mined decreased over the said period from 700 to 581; in the mean time underground and opencast mines have undergone a wide-scale re-equipment programme.

With a view to improve quality of coals, used in different branches of national economy, advanced rates of coal preparation activity growth are ensured - the tonnage of coal treated at USSR coal preparation plants in 1978 reached 344.1 million tons or 1.2 times more than in 1970.

Coal mining in the USSR is featured by adverse geology, which become more and more complicated - an average annual increase of mining depth amounts to 10 meters; by the end of 1973 work depth for the whole industry was 436 meters, while that for the Ukranian part of the Donets basin reached 585 meters. At 107 underground mines work depths were in excess of 700 meters. The share of coal output from underground mines with high gas emission rates is ever growing.

Increased level of production, mechanization and coal output concentration under the conditions of worsening geology requires further improvements in the field of management and production engineering.

Taking into account the facts mentioned above, as well as the problems suggested to be discussed it would be desirable to touch upon the following aspects, which reflect the experience gained by the USSR coal industry.

1. Improvement of analysis technique providing for the identification of production potentials and more comprehensive planning and management.

Over the last years a number of basic steps were implemented in the USSR coal industry aimed at improving analysis technique and developing systems analysis for the solution of technical and economic problems. Systems analysis is designed to reflect complex interdependent relationships between natural, technological and production engineering factors, identifying inner production resources, as well as to contribute to maximum utilization of the latter at all levels of management - from coal-winning section, mine or preparation plant up to Production Unit and Head-quarters staff of the Ministry of the coal industry of the USSR.

Basic measures implemented in the field of management and production engineering with the view to ensure high economic efficiency of the coal industry involve change-over to two or three level management system, expanded scope of Production Unit activities, establishment of Analytical Study Groups at all levels of management and cooperation with numerous Scientific and Research Institutes for conducting analytical investigations.

Central Research Institute of Economics and Scientific and Technical Information for the Coal Industry of the USSR and the Head-quarters staff of the Ministry have jointly developed methodological instructions defining the scope, sequence of work and algorithm for carrying out technical and economic analysis, covering the activity of a Production Unit as a whole, as well as the operation of separate mines or coal preparation plants.

According to the worked-out methodology, systems approach while performing analysis is provided for by integrating matrix-type interdependence of operation processes, on the one hand, and functional and correlation interdependence of production factors and resulting technical and economic indices, on the other hand.

Analysis of production potentials should compromise the following:

1. reliable quantitative assessment of effects of geological and production engineering factors on production efficiency indices, such as productivity, cost of production and profitability;

2. sound assessment of production capacity of an enterprise as a whole or of separate technological units at a given enterprise;

3. development of a set of measures, primarily in the area of production engineering, intended to eliminate so-called "bottlenecks".

Apart from operation analysis for separate enterprises and Production Units involved in coal mining or processing, analytical studies of performance records concerning capital construction, machinery manufacturing plants and transport facilities within the coal industry, as well as investigations into the availability of rolling stock, supplied by the Ministry of Railways, are carried out at special R&D institutes.

While conducting analytical studies great attention is placed upon summarizing and systemizing financial and cost accounts. Computer-based information system intended for all levels of management has been implemented, providing for information reports (published daily, weekly, monthly, quarterly, annually), that reflect the dynamics of performance records and progress in achieving plan targets within the scope of activities.

While certain successful results in the organization and methodological provision of technical and economic analysis have been achieved in the coal industry, the system of information provision needs further improvement, in particular more thorough selection of information actually needed for the appropriate levels of management, improving the reliability of information, ensuring the continuous flow of information.

2. Application of computers for management in the coal industry

Development and introduction of automated systems of management in the coal industry of the USSR is one of the major trends in improving efficiency of managment in the industry. In recent years a complicated complex of organizing and technical measures has been carried out aimed at wide-scale application of computers at all levels of management, as well as in numerous research and development establishments. Alongside with this, efforts are directed at putting in good order flows and scope of information, classifying and coding information, unification of documents, putting in good order standards and reference records, up-dating systems for transmitting input and output data.

Necessary preconditions are being created for more efficient utilization of computers in the sphere of productive activities of large industrial enterprises and production units in the coal industry. Computers are used on a wide scale in research and development.

At present within the coal industry automated systems of management nearly 200 complexes of problems are being solved, including such planning problems as calculating target figures of annual output for coal production units, optimum distribution of coal output for collieries, analysis of fulfilling coal output plans and introduction of productive capacities, solutions are being found to numerous problems on labour and wages, on calculating proceeds, on provisioning, planning, accounts and analysis of manpower deployment, product quality control, etc.

An important part of the industry-wide automated system of management is the subsystem of operational accounting and process control which ensures the solution of a complex of problems the results of which provide for making operational managing decisions prior to the expiration of plan periods (month, quarter). Alongside with the accounting problems, the subsystem ensures the control of timely reproduction of the total coal face length, efficient utilization of mechanized complexes, operation of mine ventilation networks, development of coal reserves at open-pit mines, etc.

An ever increasing importance is being attached to the application of computers in research and mine development - forecasts of long-term development of the coal industry based on the elaboration of numerous alternative options of mine design for each colliery, open-pit, preparation plant. Optimizing calculations envisaging the most economically efficient trends for the coal industry development are accomplished taking into account requirements for a technological feedstock and fuel power generation.

At present, alongside with problems of regional and industry ature, computers are successfully used for modelling individual production processes and enterprises as a whole which allows for the validity and efficiency of managing decisions to be improved if the production cycle is swerved from the present rythm and for better utilization of production potentials.

Introduction of information retrieval systems for servicing the Ministry headquarters staff and leading specialists from production units has commenced.

One of the primary scientific and practical aims, which should be solved using computers, is the improvement of methods to calculate potentials of production units and their personnel, which will allow to improve the reliability of plan calculations and to assess the degree of utilization of the available resources.

A comprehensive programme of work has been carried out in the coal industry with the aim of introducing computer methods in the practice of industry planning, this work is accomplished in coordination with the developmentof economic methods of management improvement of organization structures, instructions and other methodical materials for personnel of the planning and economic service. The major part of the work being carried out to improve planning in the industry is the development of a system of engineering, organizing and economic standards for the elaboration of current and long-term plans. Practically all main research and development Institutes are engaged in solving this problem.

Alongside with standards for direct calculations (consumption of resources per unit of production, etc.) the following important standards are being developed - ratios of potentials of technological links (which under the conditions of probability nature of a mining enterprise is a rather complicated problem to solve), terms of construction of mines of different productive capacities and in different geological conditions, terms of achieving rated technical and economic indices, etc.

Improvement of standards alongside with the expanding use of computers will be a major factor for improving the reliability of plan calculations in the coal industry.

3. Environment protection

The necessity to take efficient measures in the field of nature protection, and in particular environment protection, has been legislatively confirmed by the USSR Constitution.

In accordance with the decisions of the Communist Party and the Government of the Soviet Union aimed at protection and rational utilization of natural resources in all coal basins of the country organizing and engineering measures are being taken to protect the environment.

During the Tenth Five-Year Plan period (1976-1980) capital investments in nature protection more than trebled compared to actual expenditures in 1971-1975, over this period more than 20 thousand hectares of mined land will be recultivated, by the end of the Five-Year Plan period cleaning of effluent waters (which require cleaning) will be practically completed.

Main trends in the field of water protection from pollution by waste waters from coal industry enterprises are as follows: cleaning of effluent waters; introduction of closed circuit systems of industrial water supply eliminating emission of industrial wastes (effluents) of water streams at coal preparation plants, hydraulic mines and open pits where hydraulic method of overburden removal is employed; reducing water in-rushes to mine workings prior to and during mining operations (preliminary water drainage) maximum utilization of waste waters for industrial water supply at colliers, open-pits, coal preparation plants, cooperating enterprises and for agricultural purposes.

Special technological schemes approved by the USSR Ministry of the Coal Industry have been worked out for cleaning mine waters which provide for preliminary water clarification, filtration and hygenic treatment of clarified water and residue. In the long-term future it is envisaged to change over to deep cleaning of waste waters with subsequent utilization of waters not only for industrial but also for domestic purposes, to carry out complete treatment of wastes from effluent waters and utilization of treatment products in the national economy.

In order to prevent air pollution measures are being taken to extinguish burning spoil banks and prevent their spontaneous combustion; eliminate small boilers and set up large fuel-and-power installations for consumers; improve the technology of fuel combustion and dust extraction.

At coal preparation and briquetting plants drying installations are being equipped with highly efficient systems for dust and gas cleaning. At open-pit mines it is expected to use explosives with zero or nearly zero oxygen balance in order to reduce emission of harmful gases; technological motor transport will be equipped with special neutralizers for exhaust gas scrubbing; it is expected to use water spraying and pumping devices and different binding additives to reduce dust formation.

The coal industry is one of the most land consuming branches of the national economy. On the average, production of one million tonnes of coal is accompanied by disturbance of 7 hectares of land, mainly agricultural.

Comprehensive measures are taken in the coal industry to reduce harmful effects of mining operations upon land resources, these measures are in accordance with the USSR land legislation and instructions on protection and rational utilization of all natural resources.

One of the main trends in implementing these measures is, first of all, reduction of land areas which are disturbed in the process of working the reserves. This is achieved by the optimization of locating mines, buildings and communications in planning, construction and reconstruction of enterprises, by maximum disposal of overburden rocks in worked-out areas, by development of stowing in underground coal mining.

The scope of work on reclamation and recultivation of mined land is being expanded; at present, over four thousand hectares of mined land are reclaimed and returned for subsequent use in the national economy annually, this figure will be steadily growing. More than a half of production units run by the Coal Ministry carry out recultivation, the scope of which exceeds annual areas of disturbed land. In the long-term future it is expected to increase the scope of these operations by 2.5 to 3 times, which will allow for all previously disturbed land to be reclaimed in the next decade.

Organizing management in the field of environment protection in the coal industry is implemented by the appropriate Department of the Ministry Headquarters; research, forecasting, working out of standards in this field are carried out by a specially set up establishment - the All Union Research and Development Institute for Environment Protection in the Coal Industry.

In July 1979 the Central Committee of the Communist Party of the Soviet Union and the Council of Ministers of the USSR adopted the Resolution "On the Improvement in planning and Strengthening the Impact of the Economic Mechanism of Increasing the Efficiency and Quality of Work". This document outlines actual measures aimed at improving the level of planning in the national economy, at improving the efficiency of capital investment, at strengthening the role of economic levers and incentives.

Purposeful work being carried out in the coal industry on the realization of the Party and Government decisions will ensure further growth of the production efficiency and complete satisfaction of steadily increasing needs of the national economy in coal.

PLANNING FOR PRODUCTION: DEALING WITH UNCERTAINTY

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1. <u>The National Coal Board</u>

1.1 The UK National Coal Board operates 230 deep mines, which have an annual production of about 105 million tonnes. It uses the conventional 'line and staff' management organisation. In order to deal with so many collieries, it is necessary to divide them into 12 geographical groups called 'Areas'. There are three levels of management:

(a) the Board of Directors
(b) the 12 'Area' Directors
(c) the 230 Colliery Managers

1.2 Both the Board of Directors and each 'Area' Director has substantial staff divided according to the following functions:-

(a) production
(b) mining
(c) engineering
(d) finance
(e) marketing
(f) personnel
(g) purchasing

Each Colliery Manager's staff is very small, and contains specialists in production, engineering and personnel only.

1.3 In addition to the line and staff organisation described above there are a number of independent bodies within the National Coal Board which behave like wholly-owned subsidiary companies. The most important of these are:-

(a) The Opencast Executive
(b) Coal Products Ltd.
(c) Compower Ltd.
(d) The Mines Research and Development Establishment.
(e) The Coal Research Establishment.
(f) The Operational Research Executive.

2. <u>The Operational Research Executive</u>

The Operational Research Executive comprises 125 operational research scientists and 12 back-up staff. They are assigned to fields of work according to their customers. This means that we have little opportunity to specialise in a particular kind of problem or operational research technique, but we are able to develop good working relationships with our customers. The fields of work may be divided into four groups:-

(a) Work for national Headquarters Departments, such as mining or finance.
(b) Work for 'Area' managements.
(c) Long-Term Research, normally at our own suggestion, but with the support of two or more heads of Headquarters Departments, or of the Board of Directors.
(d) Consultancy work for other organisations.

3. Planning for Production

The work I shall describe was carried out for the management of one of the National Coal Board's 'Areas'. Throughout the period, two O.R. scientists were deployed to the 'Area'. The work occupied about $\frac{1}{2}$ man-year, spread over a period of about 3 years.

The 'Area' must plan to maximise profit within certain parameters agreed with the Board of Directors. Among these parameters are -

(a) Prices
(b) Wage Rates
(c) Total Output

The 'Area' management has control, to a greater or lesser degree, over mining methods, capital investment, recruitment, training and marketing.

We were authorised to carry out this work by the Area Director.

4. Dealing with Uncertainty

4.1 All business planning must deal with uncertainty about the outside world, concerning, for example, the cost of raw materials and the demand for the products of the business.

4.2 Business planning in the coal mining industry is further complicated by uncertainty about internal factors. If we plan to put a coalface in a particular location, we do not know:-

(a) whether the coalface can be developed
(b) how long it will last
(c) at what rate it will produce
(d) how much it will cost to operate
(e) what resources it will require, especially how many men will be required to work it.

4.3 This paper is about overcoming the internal uncertainty in coal mining for the purposes of business planning for a group of 18 mines in England. The size of the group is important. The method I shall describe depends upon the identification of sets of coalfaces with similar characteristics, and each set must have sufficient members for its average performance to be fairly stable.

4.4 The collieries in question are in general quite small. They have a combined labour force of about 17,000, and produce about 8.5 million tonnes per year, mainly of coking coals, from about 50 longwall mechanised faces operating in seams between 0.9 and 2.0 metres thick.

4.5 The essence of business planning is forecasting the outcome of alternative plans in terms of output, manpower and costs. In this paper, I shall deal only with output and manpower forecasts for a period of five years ahead.

4.6 In searching for a better way of forecasting output and manpower requirements, we have first to understand the reasons for our current output and manpower levels. This cannot be done in an absolute sense, but some progress can be made by analysing changes that have taken place in recent years.

5. Historical Analysis

A vast body of data exists. We used a computer program to analyse it in every conceivable way. Knowing the changes in output, face manshifts and total manshifts for the group over the previous ten years, we sought to explain them in terms of -

(a) Seams worked.
(b) Face dimensions, and number of faces in production.
(c) Mining methods.
(d) Attitudes of men.
(e) Rules and regulations.
(f) Markets, and Coal Preparation Techniques.

Not all of these were important. A summary of the important results of the analysis is given at Appendix A. These results apply only to the 18 collieries in question. Another group would give quite different results, because its geological circumstances, mining techniques and management philosophy would have developed differently, and it might have been subjected to different attitudes amongst the men, and so on.

We are not operating in scientific theory, where we might demand to be convinced with 99% confidence of each result. It is necessary to form some conclusion even when the evidence is weak. Some of the evidence for the conclusions given in Appendix A is not very strong, but the conclusions have proved to be good working hypotheses, which we may hope to improve in later years as our understanding and/or information improves.

The dominant feature of our findings was that apparently haphazard variations in production and productivity can be explained by stability or slow and steady change in a number of inter-related factors. Furthermore, a number of factors which were previously regarded as important were shown to be negligible - this was a great relief, for some of them cannot be measured, let alone forecast. The analysis used three sets of coalfaces (thin-seam advancing, thick-seam advancing, and retreat); each set showed reasonable stability in face performance; there were great differences between sets.

6. Forecasting Model

6.1 Description of the Model

We used the stability of various factors discovered in the historical analysis to construct a forecasting model for output and manpower. All that is required from future plans is:-

(a) face start and finish dates.
(b) face lengths and extracted sections.
(c) market changes.

The model is built up in stages, and works on the three sets of coalfaces mentioned in section 5. Calculations are performed for each face, so as to prevent inaccuracy arising from interaction between face length and extracted section. The forecast for each individual coalface is quite worthless, but the aggregate forecast for the group of collieries is the best that can possibly be made with current knowledge.

Appendix B gives details of the calculations performed for each of the three sets of coalfaces. The only serious outstanding source of inaccuracy is the reliance on planned face start and finish dates.

The model was computerised for speed of calculation, and to take advantage of the general air of authority which computer printouts have.

6.2 Accuracy of the Model

The first time we were able to compare actual results with our forecasts, for the first year of a five-year plan, our forecast was 3% out on output, 1% out on face manshifts. The second year, we had to contend with a productivity incentive scheme for mineworkers and some surprising market changes, which left us a little further adrift. Nevertheless, our forecasts were more accurate than those produced by the traditional method , so that our forecasts for up to five years ahead were studied with great interest by the group's managers.

6.3 Use of the Model

The most important use of the model to date is in identifying a gap between the output required of the group and what it seemed likely to achieve over the next five years. This led on to an investigation of ways of filling that gap - by increasing the number of faces in the plan, or the machine shifts to be worked per face day, or the lengths of some of the faces. Each of these investigations requires work outside the model. For example, if you wish to consider having more faces, you must decide where they can be put. We were able to describe various ways of filling the gap, and recommend certain courses of action, some of which were adopted by the group's management.

The model is now well established, and will continue to be used regularly even if no time is found to develop it further. It has provided a better grasp of what is likely to happen by attacking the internal uncertainty of coal mining in a commonsense manner.

7. Future Developments

In the future, the historical analysis must be kept up to date, and the forecasting model must be changed as the results of the historical analysis dictate. It is reasonable to hope that there will be refinements to the model, particularly as regards face start and finish times and non-face underground manshifts.

Our final aim must be to produce a fully-fledged business planning model. This would require additions to the model of appalling complexity, in the areas of operating costs and capital investment schemes. It may be that we shall never have sufficient time to undertake this work, for it must now be obvious that the serious application of operational research to planning for production is a very strenuous business indeed.

8. Conclusions

(a) There is no general answer to the problem of how to plan a mining business - the answer depends too much on the geological circumstances, mining methods, and managerial philosophy of the mines in question.

(b) The correct answer for any given group of mines is only to be found after energetic analysis over a long period.

(c) Unless you have quite a large group of mines, the internal uncertainty of mining will prevent your forecasts being sufficiently accurate to command attention.

(d) If you have a sufficiently large group of mines, systems analysis can contribute a great deal to the business planning of the mining industry by tackling the internal uncertainty of mining in a sensible manner.

I. R. TURNER
October, 1979.

APPENDIX A

Results of Historical Analysis

Using a computer program to analyse a vast body of data in every conceivable way, the following results were compiled. They apply only to the group of 18 collieries in question. Another group would give quite different results. We are not operating in scientific theory, where we might demand to be convinced with 99% confidence of each result. It is necessary to form some conclusion even where the evidence is weak.

(a) Proportion of Planned Faces in Production

If we plan to have n faces in production on any given day in the next five years, we should expect, on that day, to work .92n face days.

(b) Advancing Faces

(i) Advance per machine shift is independent of face length. This is not to say that all faces could be made longer without prejudice to the rate of advance, but that where suitable places for long faces are found, they advance as quickly as would shorter faces in the same places.

(ii) Advance per machine shift is heavily dependent on extracted section, and in fact the group's advancing faces may be divided into two sets (thin seam and thick seam) with remarkably different, and quite stable performance characteristics. See graph 1.

(iii) For each of these two sets of advancing faces, advance per machine shift is slightly dependent on the number of machine shifts worked per face day, and the dependency can be fairly described by a linear expression derived from a simple regression.

(c) Retreat Faces

(i) The square metres (length x advance) extracted from a machine shift on a retreat face of length L are expected to be in accordance with a commonsense formula of the kind

$$\frac{aL}{L + B}$$ where a, B are constants.

See graph 2. This result was derived from British national data, and required some slight adjustment for the group of collieries in question. The group had insufficient retreat faces to allow a conclusion to be drawn from its own data.

(ii) The square metres extracted per machine shift are independent of the number of machine shifts worked per day. There may be a relationship with extracted section, but we have not yet found one.

(d) Face Manshifts

For each of the three sets of faces (thin-seam advance, thick-seam advance, and retreat), the manshifts worked per machine shift have been stable in recent years, following a reduction upon the introduction of stable-hole elimination. There is, of course, in each case a dependency on machine shifts worked per face day, which may be fairly described by a linear relationship derived from a simple regression.

(e) Other Manshifts

Surface manshifts exhibit monumental stability. Non-face underground manshifts show a steady rise as distances from pit-bottom to face increase, and as more effort is devoted to the field of health and safety. They also show great stability when the number of faces in production changes.

(f) Saleable Output

(i) The proportion of coal in the average worked section for each of the three sets of faces has varied over the years in an orderly, and apparently predictable, fashion. That is to say, the seams are getting dirtier.

(ii) The saleable tonnage derived from each cubic metre of coal extracted has been fixed for several years (there have been no important market changes).

(iii) In addition to the coal produced from longwall mechanised faces, there is a constant proportion (4%) of coal produced from drivages.

(g) Mining Techniques and Geological Circumstances

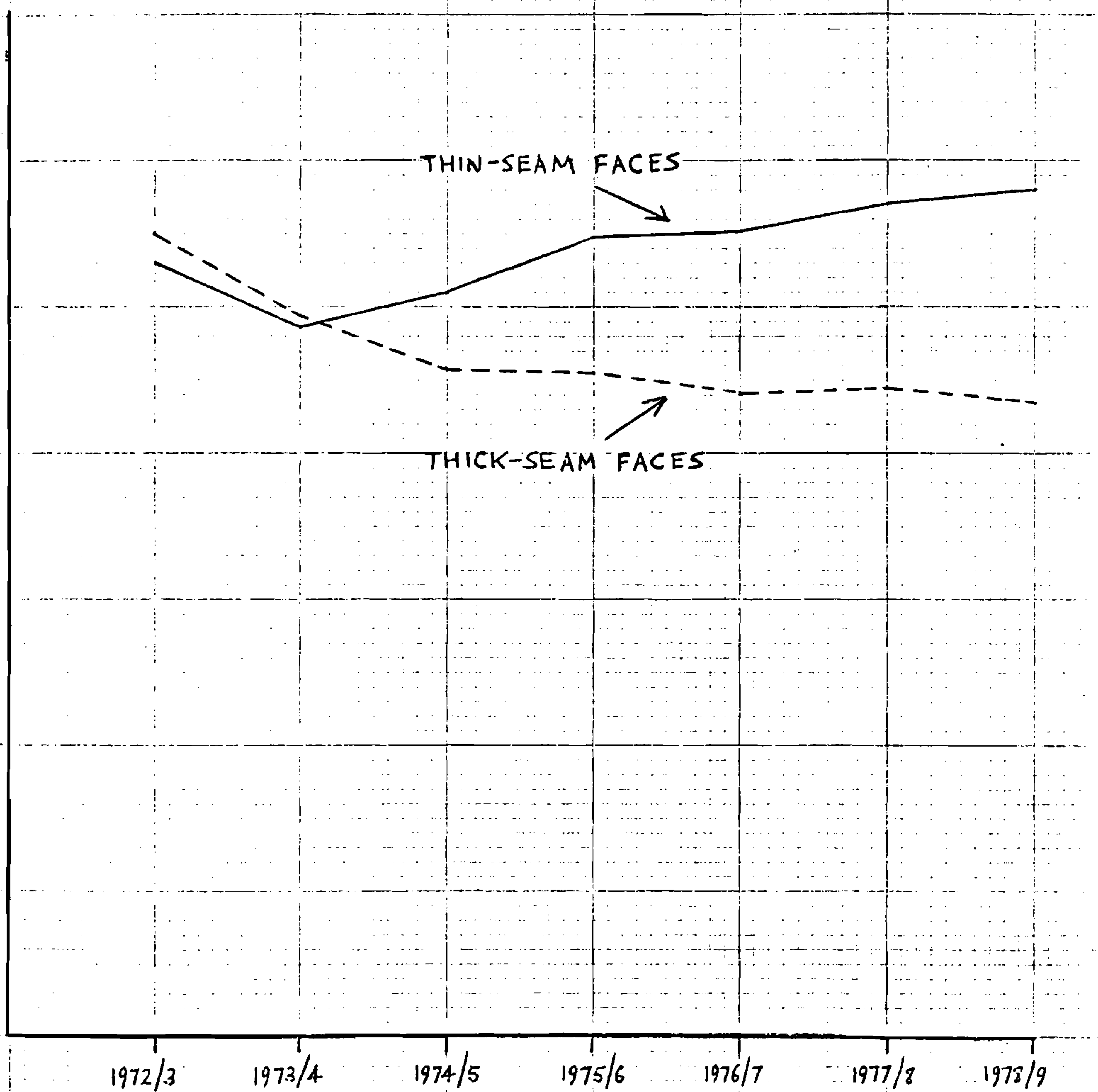
Changes in mining techniques and geological circumstances have been slow and orderly in recent years. When confronted by new mining techniques or geological circumstances in future, we should eschew both panic and euphoria. The best approach is to continue to assume that no change in face performance will occur until strong evidence in support of a change has been recorded.

(h) Manpower Effort

All of the changes in production and productivity in recent years can be explained without postulating any change in the level of effort offered by mineworkers.

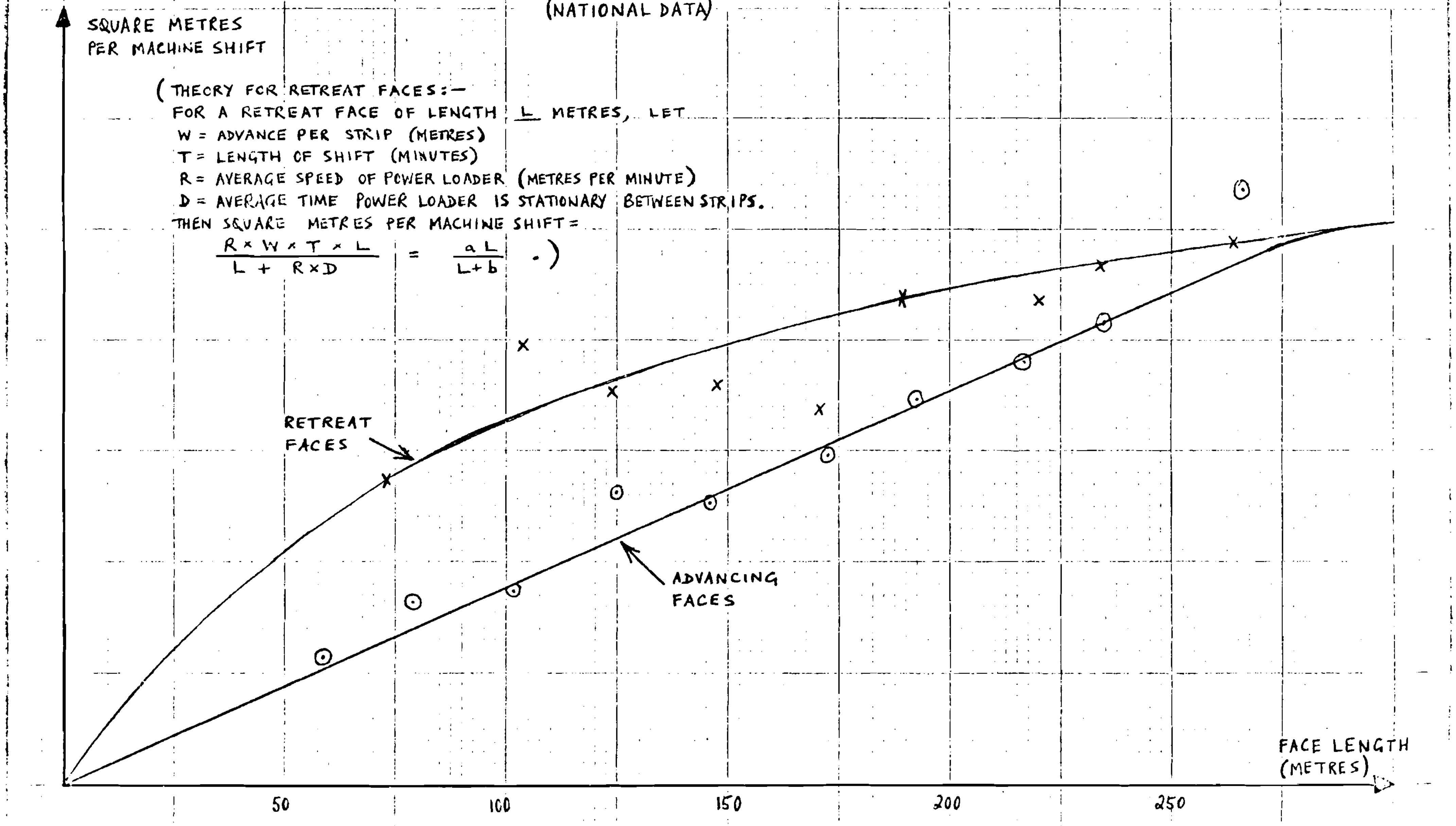
GRAPH 1 - FACE ADVANCE PER MACHINE SHIFT

ADVANCING FACES IN 2 SETS



GRAPH 2 SQUARE METRES EXTRACTED PER MACHINE SHIFT vs FACE LENGTH

(NATIONAL DATA)



APPENDIX B

Calculations performed in the forecasting model for each planned face in each year up to 5 years ahead.

1. Advancing Faces (There are two sets of advancing faces - thin seam and thick seam)

Result	Factor	Notes
(a) Face Days =	.92 x	(Shortfall on plan - from historical analysis)
	Group Working Days in the Year x	(From the plan)
	Planned Months in Production /12.	(From the plan)
(b) Machine Shifts =	Face Days x	(From (a))
	Machine Shifts per Face Day	(Input to the model, but normally as indicated by historical analysis; different for the two sets of advancing faces.)
(c) Advance per Machine Shift =	Linear Function of Machine Shifts per Face Day.	(Linear functions are derived from historical analysis; they are different for the two sets of advancing faces).
(d) Saleable Output =	Machine Shifts x	(From (b))
	Coal Section Worked x	(Total worked section from the plan, different proportion of coal in total section for each set of advancing faces from the historical analysis.)
	Face Length x	(From the plan)
	Advance per Machine Shift x	(From (c))
	Saleable Tonnes per Cubic Metre of Coal Extracted from Longwall, Mechanised Faces	(Input to the model, but normally as indicated by the historical analysis).
(e) Manshifts per Machine Shift =	Linear Function of Machine Shifts per Face Day	(Linear functions are derived from historical analysis; they are different for the two sets of advancing faces.)
(f) Face Manshifts =	Machine Shifts x	(From (b)).
	Manshifts per Machine Shift	(From (e)).

2. Retreat Faces (Treated as only one set)

Result	Factor	Notes
(a) Face Days	.92 x	(Shortfall on plan - from historical analysis).
	Group Working Days in the Year x	(From the plan)
	Planned Months in Production /12	(From the plan)
(b) Machine Shifts	Face Days x	(From (a))
	Machine Shifts per Face Day	(Input to the model, but normally as indicated by the historical analysis).
(c) Square Metres per Machine Shift =	$\frac{aL}{L+b}$ where L = face length and a, b are constants	(Function derived from historical analysis of national data, and adjusted for the relevant group of collieries)
(d) Saleable Output =	Machine Shifts x	(From (b))
	Coal Section Worked x	(Total worked section from the plan; proportion of coal in total section from the historical analysis)
	Square Metres per Machine Shifts x	(From (c))
	Saleable Tonnes per Cubic Metre of Coal Extracted from Longwall Mechanised Faces	(Input to the model, but normally as indicated by the historical analysis)
(e) Manshifts per Machine Shift =	Linear Function of Machine Shifts per Face Day	(Linear Function derived from the historical analysis)
(f) Face Manshifts =	Machine Shifts x	(From (b))
	Manshifts per Machine Shift	(From (e))

OR IN NEW MINE PLANNING

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INTRODUCTION

In the mid-1970's a major new prospect was proved in a previously unworked region of North East Leicestershire, United Kingdom. Preliminary estimates from borehole information showed over 500 million tonnes of recoverable reserves. A special Planning Team was set up, to co-ordinate the work for the two local Areas, South Nottinghamshire and South Midlands (management of production of the UK National Coal Board is organised in twelve such Areas). The team was led by one of the authors as Deputy Director, Mining, North East Leicestershire Prospect (NELP).

The remit imposed by the National Coal Board was to analyse the possible options of number, location and eventual rates of output of shaft or drift access; to select a recommended alternative in the light of geological, mining, topographical and environmental considerations; and prepare submissions in accordance with standard Board practice on major projects - such submissions including detailed engineering design, financial appraisal, and full risk assessment. To assist the Planning Team, surface and underground consultant engineers were appointed to prepare feasibility studies of specific civil and engineering problems.

In late 1976 a small Operational Research team led by the second author was seconded to NELP. The Operational Research Executive (ORE) of the National Coal Board has a long history of involvement in colliery planning. It is impossible to give full documentation here, but references (1) to (5) give examples of techniques developed by ORE, widely used throughout the National Coal Board in the planning of existing collieries. This close involvement arose through

(a) small teams allocated to each Area, concerned with both overall Area policy, and planning and operational problems arising at individual collieries within the Area;

(b) research teams sponsored by Headquarters Departments such as Mining Department, the research being intended for ultimate use throughout the industry.

The OR team became a local team attached to NELP, but it was never forgotten that all work should eventually prove applicable to other new mines and major extensions required under the UK Plan for Coal and Plan 2000. This paper describes the OR methods developed and used at NELP, in six sections:

- Reserves assessment

- Underground layout assessment
- Manpower availability
- Manpower requirements and productivity
- Surface capacities
- Financial assessment.

We then go on to discuss the general applicability of these techniques, and the reasons why they are of assistance in new capacity planning, from the points of view of both mining engineer and OR scientist.

RESERVES ASSESSMENT

In the early stages of planning a prospect such as NELP it is necessary to produce, from the borehole data, maps showing the distribution in quality and quantity of the coal within the take. The access points and the rates of extraction to be considered will be influenced by these assessments of reserves distribution. Later, in the more detailed stages of planning, more accurate estimates are required so that projections can be made of output quantity and quality over the lifetime of the prospect for any proposed layout and phasing of the underground workings.

The complete behaviour of the target seams is best described by the isopachyte maps prepared by the geologist, and it is an essential task to update these continually as new information comes to light. However the length of time required to produce isopachyte maps causes problems when complications of seam structure make it necessary to consider a range of different mining assumptions. At the stage of detailed mine planning, the maps are in any case not always the most convenient form in which to present the information. This results in large amounts of the geologist's time being taken up in the routine calculations required to translate the information from the isopachyte map into estimates of output quality and quantity.

To overcome the above problems, a computer system Geoplan was developed to facilitate the preparation of summary analyses which give an immediate impression of size, distribution and quality of reserves, and to assist in the detailed calculation of year-by-year output estimates. The basic principle of Geoplan is that of interpolating borehole information to a square grid superimposed over the site (typically the grid size used is 1 km). This principle is of course not new, and the method of interpolation, averaging weighted by $1/D^2$, has also been used extensively. What was new in Geoplan was that the system was designed so that it could be used before the geologists had performed the detailed and time-consuming correlation of individual partings in borehole logs. (The second innovation was the immediate development of underground layout assessment described below.)

From the borehole logs the system first estimates the ash and dirt content at each borehole in each seam for a specified range of working sections (at NELP this was from 1 to 3 metres in 25 cm steps). The sections are normally positioned leaving a specified roof coal, but an option exists to position the section so as to minimise ash. Any section which finishes in dirt (either floor or dirt band) is reduced. The borehole information is now interpolated to grid squares by weighting the readings from the three nearest boreholes. The geologist now assesses the grid-square maps of the seams, and has the option to input dummy boreholes to improve the estimates in regions of seam splitting or thinning. There are good reasons why $1/D^2$ averaging is an insufficient model in such regions; in particular seam splits tend to increase exponentially in the direction of the split.

Much detailed information can be obtained once the grid-square estimates are available. For each seam and for each possible section, one map of corresponding ash and one of corresponding dirt are available. Also produced are maps of the corresponding reserves, assuming the given section and a relaxation factor for incomplete extraction in the square. The same information can be usefully portrayed in an alternative way: the maximum available working section (and associated ash, dirt etc.) that can be worked for a range of ash limits (for example 10% to 30% in steps of 5%). All this information can be available quickly after the borehole logs are received. Thus, very early in the planning process, the geologist and mine planners can obtain a close understanding of how section, ash and reserves will vary across the take, and use this information in analysing alternatives in access location and rates of extraction. At the same time, it is easy to prepare summary analyses which give an immediate impression of section or reserves distribution. Figure 1 shows one possible example.

UNDERGROUND LAYOUT ASSESSMENT

The second half of Geoplan allows mine planners to assess the performance of any proposed underground layout. A method has been devised so that the face by face plan of working can be superimposed on the grid square data base. For an existing mine this would be an extremely tedious process, because the geometry of the present day position and the history of previous workings mean that future faces can only be described individually. However, for a new mine, especially in the early stages of the planning process, fewer such restrictions will apply, and often the description of future workings will be in terms of large blocks and sequences of faces of similar geometry. In such circumstances the working of large areas of coal,

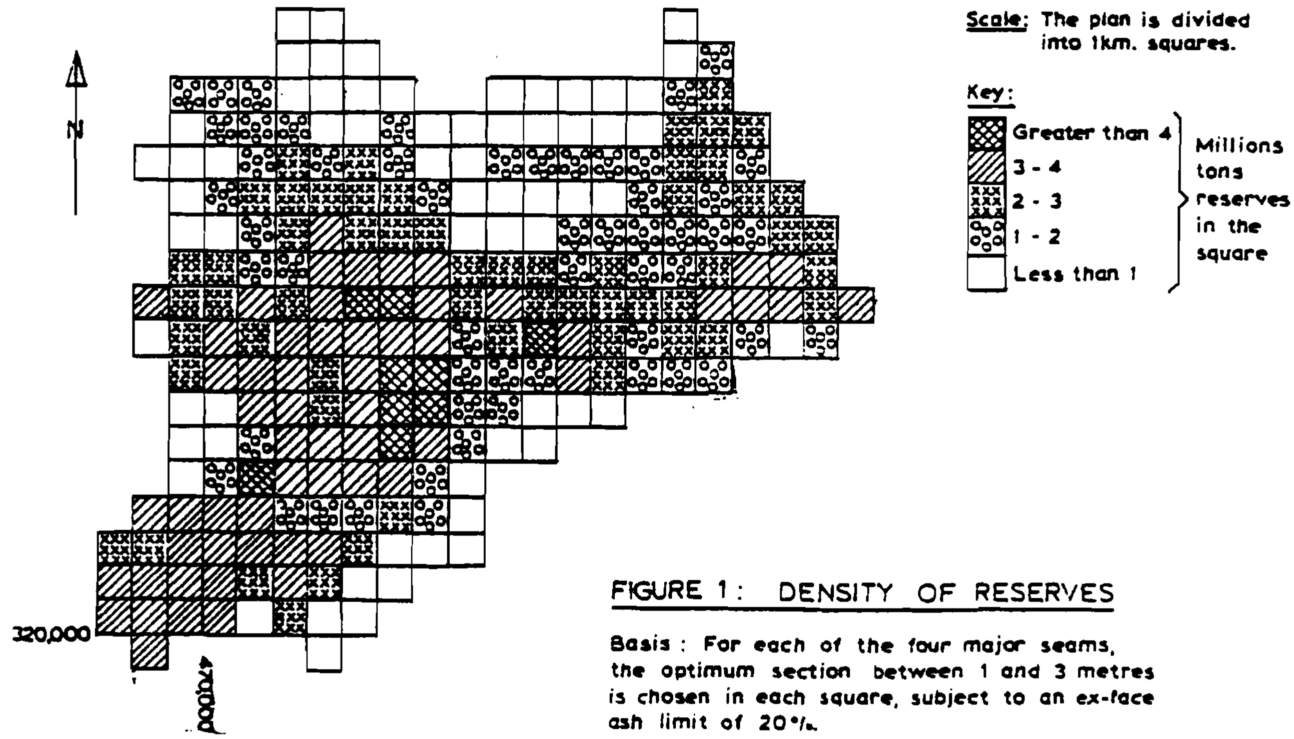

FIGURE 1: DENSITY OF RESERVES

Basis : For each of the four major seams, the optimum section between 1 and 3 metres is chosen in each square, subject to an ex-face ash limit of 20%.

taking up significant time periods of the proposed colliery workings, can be uniquely specified using very few data items.

Given the machine-shifting pattern and assumptions on advance per machine-shift, the computer program calculates how the faces and sequences advance, year by year, through the grid squares. In this way annual estimates of output ash and dirt from each face can be produced. These are summed, together with calculations of separate dirt production, to give estimates of colliery run of mine quantity and quality year by year. If the run of mine forecasts are not satisfactory (for example, there may be a few consecutive years with consistently high ash), the mine planner can input an adjustment to the layout, or the machine-shifting pattern, so as better to balance production from 'better' and 'worse' areas of the take.

Finally, the run of mine forecasts can be converted to forecasts of saleable production, using a model of coal preparation operations. The usual use of this facility is to define the target calorific value of the product, and to determine, given the forecasts of run of mine quantity and quality, the requirement in terms of coal preparation capacity and operating policy, and the consequent ratio of saleable to run of mine (vend). Such estimates are essential from the earliest stages of prospect planning, as the initial options of size of mine and their capital cost are being identified and evaluated.

The two halves of Geoplan could exist independently and prospects have been identified where the primary benefit arises from the use of one or the other without linking. However the full potential of the computer system is only realised when both reserves and underground layout assessment are considered in tandem; only in this manner can we adequately reflect the fact that reserves in a specific area, and the consequent annual rates of production from that area, can only be fully evaluated in the context of the proposed method of working and its phasing.

MANPOWER AVAILABILITY

The build up of a recruitment and training programme requires a considerable amount of calculation to establish the levels of recruitment of different categories of worker which would provide the required levels of manpower. These categories include those with previous mining experience, long-distance transferees and transfers from any local collieries, and those who are new to the industry, juveniles and new adults from the catchment area around the prospect. Recruitment problems are exacerbated in new mines in new areas for a number of reasons: wastage rates, particularly of new adults, will tend to be high, and lead to a high ratio of total recruitment in the build-up years to the stable men on books level; the rapid build up to full production necessary to ensure a quick return on capital may result in annual jumps in requirements that exceed the sum of availability of all categories, unless there is careful planning of transfers from local collieries; equally this rapid build-up may result in too high a proportion of labour undergoing training, when in fact it is precisely in these years when a high proportion of key skilled face and development teams are required; finally, the recruitment must be carefully assessed in the light of the provision of new housing already or potentially contained in Local Authority Structure Programmes.

The use of a computer model, Bildup, has greatly eased the task of analysing manpower availability problems at new mines. The model uses estimates of availability and wastage rates for each category of worker in order to match recruitment with requirement year by year. Provision for a proportion of those wasting to re-enter is included. Usually those availabilities governed by NCB policy (local transfers, long distance transfers, and juveniles) are estimated independently, and then the model is run to derive the year-by-year requirement of new adults. This can be then compared with Department of Employment assessments of recruitment potential for new adults given the specification of the catchment area and likely wage relativities. The build up of new adults on books can also be assessed in the light of the special requirements for key skilled labour described above. If, for either reason, the new adult profile is untenable, the recruitment program must be reassessed and changes in policy established.

Figure 2 shows the results of such an exercise. The bold histogram shows the new adult requirements calculated from an initial run, while the dotted histogram shows the results after several exercises changing policy and therefore assumptions. These policy changes include:

(a) changing the phasing of transfers from local collieries;

(b) changing the allocation of transfers (both local and long distance) between the individual pits making up the prospect;

(c) introducing specific actions so as to increase the transfer and retention rates that can be assumed.

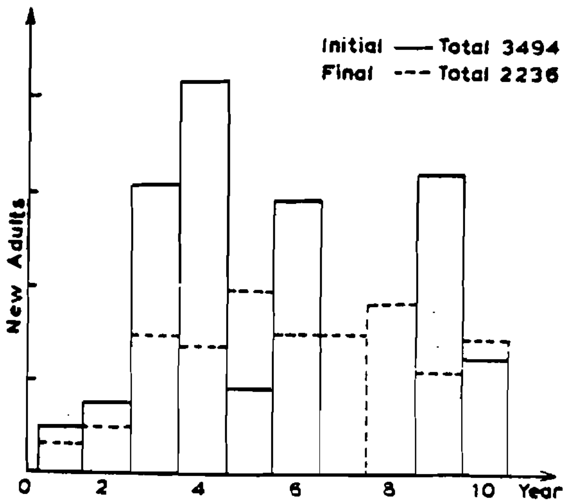

FIGURE 2 : NEW ADULT REQUIREMENT

It will be seen that the dotted histogram requires far fewer new adults in the maximum years, while at the same time representing a much steadier recruitment programme.

MANPOWER REQUIREMENTS AND PRODUCTIVITY

The relationship between required output and manpower requirements is important in all stages of the planning of a new mine or major prospect. If recruitment is at all likely to be a problem, the requirements may be as significant in determining eventual rates of output as coal reserves distribution or environmental factors, and estimates are needed as soon as planning commences. As planning progresses, there will be continuous changes in the geological, mining and manning assumptions and information, and it is essential that the relationship between output and manpower is correspondingly updated.

Conventionally there are two methods of determining this relationship. In the early stages of planning, requirements are first calculated by combining a preliminary estimate of output per manshift (OMS) with the preliminary output estimate. As geological interpretation progresses, and the first underground layouts are prepared, manpower requirements are then re-estimated by detailed Job Analyses, which seek to locate on the layout the place of employment of every required shift.

The drawback with OMS is that the initial estimate may not be reliable. There are no reasons why productivity in the prospect in question should be similar to that of other new mines, or close to that of nearby existing pits. Conditions may be completely different. Further, as geology, mining and manning assumptions change, it is not a straightforward matter to estimate how these changes affect the OMS estimate. Job analyses, on the other hand, require too much time and effort, such factors militating against analysis of alternatives or reassessments in the light of changed information. In addition, if manpower availability studies imply an upper limit or manpower constraint, there is no simple way to reverse the calculations to discover the corresponding constraints on output.

In the case of new mine research, we have developed a computerised method of linking output and manpower requirements which overcomes these difficulties. It draws on the strengths of Job Analyses, by assuming that there is no simple relationship between output and manpower while making simplifying assumptions so that analysis is not layout dependent. The essentials of the methods are as follows:

(a) Saleable tons/machine shift is derived from planned face geometry, geological information, and assumptions on face advance rates. This is repeated for both advance and retreat faces.

(b) Given the output requirement and the proposed proportion of retreat working, the required number of production machine-shifts can now be derived. This can be converted to a face requirement, taking into account the provisioning of spare capacity in the form of faces and/ or shifts.

(c) The associated development requirement is derived from face geometry and assumptions on development and face advance rates.

(d) Face and elsewhere below ground (EBG) shifts are specified per production machine shift, per face and per development machine shift. Given the calculations from the steps above, face and EBG shifts can be derived. Constant EBG shifts independent of production and development are added. Surface shifts are usually taken as a constant requirement, although a proportion varying with output can be included.

(e) Shifts are converted to men-on-books requirements using the respective rates of non-deployment and overtime.

Since all the relationships are linear, it is possible to work the whole model in reverse. Thus, if the analysis from using the Bildup program implies a limit on total availability, the consequent machine shifts that it is possible to work, and the consequent saleable tonnage, can be derived.

Figure 3 shows one example of the extremely powerful sensitivity analysis that can be performed using this computer model. Lines of constant manpower requirement for a given target output are plotted as development performance and face performance (strips/ shift) vary from 100% of their central estimate. Thus the robustness of the manpower plan with respect to two key parameters is concisely and conveniently depicted. (A different family of curves would be produced if other assumptions - e.g. retreat percentage, or levels of absence and overtime - were allowed to vary.) An analogous family of curves of constant saleable output can be derived if there is a perceived manpower limit.

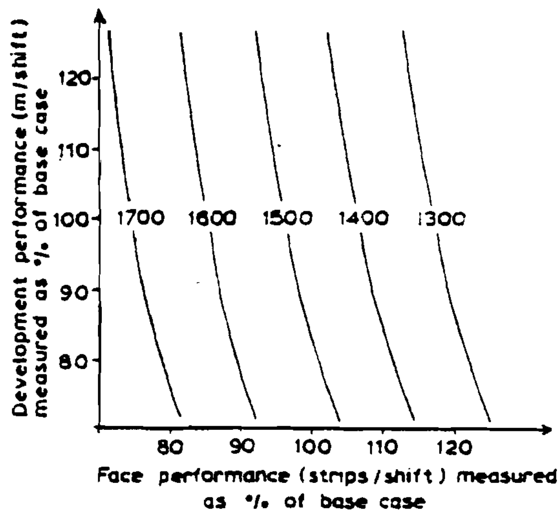

FIGURE 3 : MANPOWER REQUIREMENTS (MOB) FOR 2 MILLION TONNES P.A. AT DIFFERENT LEVELS OF PERFORMANCE.

SURFACE CAPACITIES

At all stages in the flow of coal from face to railway wagon there are decisions in balancing insurance against size and capital cost of the equipment involved. These decisions are not of the same order as the questions of size of mine being considered in earlier sections; rather, they are concerned with determining capacities in the light of short run variability in coal flows once the basic or average level of operations has been established. However, the capital costs involved are so huge that significant savings can still be achieved with proper design, for any given overall plan. Computer simulations to determine sizes of underground belts and bunkers have long been in use within the NCB and have also been used to determine bunker capacities on the surface. However, the scale of the problems of surface design in new mine planning required the development of new simulation programs that would consider the overall system from shaft to wagon.

Many individual problems can arise within overall system considerations. For example, there is the question of the homogenisation of run of mine coal of high ash variability, before feed into the coal preparation plant. Two completely different systems are possible: surge/homogenising bunkers where the bunker is divided into a number of cells filled in rotation, while feed to the coal preparation plant is drawn simultaneously from each cell; and travelling stacker/barrel reclaim systems where coal is layered down in long horizontal piles and reclaimed in cross-section by a barrel travelling on rails. A second problem is the provisioning of adequate maintenance of each of the streams of the coal preparation plant. Depending upon the assumptions made on maintenance requirements and working outside of normal washing hours, there arises the possibility of a maintenance stream system, in which there is a permanent extra stream so that one stream is always undergoing maintenance. This stream would not be available in the case of breakdown of one of the working streams. A third problem is the required number, size and control rules of rapid loading bunkers, in situations where a far greater number of daily trains are being loaded than is normal in current systems.

Some of thsse problems can be considered individually using detailed simulation models analysing for example, a day's operation in fifteen minute intervals. More usually, however, it has been found that the robustness of the performance of a particular configuration can only be fully evaluated by complete simulations of the overall surface system over several days. It is impossible, for example, to separate the question of the potential and capacity of a layer blending system from the question of the number and size of coal preparation plant streams.

In such new mine analysis, the normal problems of data collection are intensified. It is extremely difficult to establish agreed means and distributions of breakdown rates for machinery or systems that for reasons of size or technology are not in common current use. Similarly, an imprecise definition of required performance precludes optimisation. The interruption of winding because of an impediment in the surface flows is an emergency to be avoided at almost any cost, but within the limit of definable emergencies to be avoided there is a continuous range of situations that will occur once in so many days. Essentially, the pay-off between capital cost and performance can only be a matter of management judgement; the function of the simulation is to describe the performance of each of the conjectured configurations under the possible control rules, breakdown rates, train arrival patterns etc. - such analysis being impossible in the time available without the use of simulation.

Figure 4 illustrates such an exercise, analysing the effects of varying capacity of coal preparation streams. The indicator of performance in this particular problem has been taken to be the number of days per hundred days that coal can be expected to be laid down outside the two main piles of a travelling stacker/barrel reclaim system. Such an occurrence would not necessarily represent an emergency, in that the design can include facilities for transverse railings such that the barrel can reclaim from outside the normal area; nevertheless, it indicates that the overall system is out of balance.

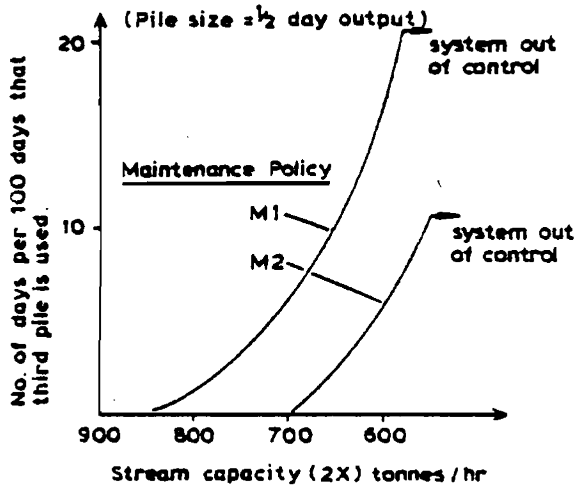

FIGURE 4 :

REQUIRED COAL PREPARATION CAPACITY.

FINANCIAL ASSESSMENT

One of the most important methods of obtaining an overall assessment of a major prospect is discounted cash flow analysis. Such analysis can be equally useful both in isolating the sensitive areas of an individual plan, or in comparing the overall strengths and weaknesses of alternatives. Unfortunately, the calculations cannot be performed until all the relevant information on the project has been assembled, and often this can only be at the very end of the planning period specified. Thus at a very important stage of project appraisal management may be short of sufficient time to analyse the sensitive areas of the project as thoroughly as they might wish.

To alleviate these problems, we have developed a financial modelling system adapted to the special considerations of new mines. Use of financial models is widespread throughout industry and a description of the new mine version would not be worthwhile here. However a number of aspects of more detailed use of the system, over and above the normal requirements of project appraisal, are worthy of note.

One part of the system deals with DCF breakeven analysis. The planner can ascertain the proportional increase (or decrease) that must be incurred by important parameters such as proceeds, capital or productivity, in order that the project shows a pre-defined yardstick of profitability (expressed as a particular value of the yield). To facilitate such analysis, the manpower requirements model described earlier has been built into the financial assessment system, and a typical problem that can be analysed is: How would an increase in mined section (at the expense of overall vend) affect the productivity, and through that the machine shifting requirements, manpower requirements, and overall profitability?

Secondly, we have promoted increasing use of the system earlier in the planning process, so that now the system is often used for the preliminary analysis of options at a new prospect. At such a time, the information input is necessarily uncertain and rough, but rankings of the different options can be constructed. We would not claim that such an approach is always useful; for example, choice between a shaft and a drift in a specific instance ultimately depends on cost alone, but the issues are often best expressed in non-financial terms. However, the construction of such rankings can be of great assistance in determining the relative sizes of the different possible access points in cases where the prospect is likely to be worked from more than one.

Thirdly, involvement in the general field of financial sensitivity and robustness testing had led to tentative application of classical risk analysis techniques. This has arisen through the attempt to improve the standard method of project submission, which is to prepare a 'base case' or 'central estimate', and then to apply sensitivity tests by varying appropriate key parameters by given percentages. Such an approach gives no indication of the relative probabilities of the different outcomes; more fundamentally information is lost in that the 'base case' may well represent the most likely outcome but may be significantly different from the expected outcome. At the least, full risk analysis gives management a thorough summary of the confidence that can be attached to particular outcomes for a given project; the full potential lies when the different options are being compared. Depending on management's attitude to risk, it is possible that the consequent decisions taken may be completely different from those that would have been taken conventionally.

THE VALUE OF OR IN NEW MINE PLANNING

The use of OR methods and computer models, such as those described in previous sections, is often promoted under the general benefits of allowing more analysis of alternatives within any given time. This is an over-simplification, and it is useful to attempt a more rigorous analysis. In particular, such analysis can give indications of where further research is needed.

Great care was taken in the description of the different applications to set them in the context of the difficulties encountered by mining engineers in solving the complex optimisation problem of planning a new mine. The most obvious difficulty is the uncertainty, both in knowledge of the fixed world of the geological structure of the prospect, and in estimating the future technologies, productivities and costs. Secondly, there is the general question of quantifying, and identifying the influence of, the constraints inherent in the system being analysed. Superimposed on these are questions of information flow. At the simplest level, it is extremely difficult to ensure that the consequences of changes in estimates are followed through thoroughly, and the complexity of the task discourages the undertaking of adequate sensitivity analysis. Information may be incompatible - it is extremely difficult in questions of location of access sites to combine underground mining criteria with those arising from considerations of surface topography and environment. Lastly there are the genuine difficulties of communication of information between different specialisms in a form useful to both sides.

The consequences of these difficulties are well known. Specificity leads to commitment, and a favoured, fixed option tends to emerge too early. By careful division of the overall problem into sub-problems, these difficulties can be overcome. The key lies in the precise identification of the information flows between sub-problems. The effect of constraints can now be analysed, in that the consequent direction of flow of information between sub-problems can be determined. This allows a network to be set up which broadly specifies the order in which effort should be allocated to the different sub-problems. In this way decisions are made, as far as possible, on the best information given the time available.

The above systems analysis is useful in itself, but when it is combined with specific OR methods the contributions that can be made to mine planning are enormous. It will be seen that the applications described in this paper are of four types:

(a) Those which allow individual sub-problems to be analysed more quickly and completely. This is essentially the 'more alternatives' argument, and an example is the manpower availability computer system, Bildup.

(b) Those where the OR method involves much more detailed analysis of a sub-problem than is possible otherwise. In this category falls the computer simulations of surface coal flows; the analysis would simply not be possible without the use of the simulation technique.

(c) Those which aid the analysis of the interaction between different sub-problems by correctly identifying the required information flows. In this category lies Geoplan; one of the main reasons for its success lies in the construction of a data base that is compatible with the requirements of the different specialisms of geology and mine layout planning.

(d) Those which show the dependence of information flowing from one sub-problem to another on the assumptions made in either sub-problem. An example here is the model of manpower requirements and productivity; the reason for its development was to improve analysis which had previously assumed that OMS could be regarded as an exogenous variable linking manpower and output.

FURTHER APPLICATIONS

The OR models described in this paper were all developed at one particular new mine prospect. Effort in the last year or so has concentrated on testing whether these models can be implemented generally at other prospective new mines and major expansions. Implementation has been successful; and in particular there has been encouraging progress in two separate directions. Firstly the models are being used increasingly early in the planning process, and are making an increasing contribution to the vital early decisions. (In the first applications they were by necessity used more to test the sensitivity of an already fairly well-defined plan.) Secondly, they are being proved applicable to problems of smaller-scale expansions at existing collieries. If such a trend continues, we can look forward to a time when at least some of the models described might be of use in the planning of all collieries.

In the course of such dissemination, much further research has and will be generated. Existing models will have to be adapted and expanded to cater for specific new problems encountered at particular prospects. In addition, involvement at other prospects will define those areas where research is required to fill gaps not covered by the present range of models. The identification of research requirements, and the balance between implementation and new research, will be continuously monitored and appraised by ORE and their sponsors in the Mining Department of the National Coal Board.

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COMPUTERIZED DESIGNING PROCESSES FOR THE DEVELOPMENT OF COAL REGIONS AND COAL MINES

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1. Introduction

Computers, and especially the electronic digital computers, have enabled to introduce modern methods of applied mathematics and to utilize a great number of quantitative and qualitative information data in design works. Therefore, the Główne Biuro Studiów i Projektów Górniczych - GBSiPG /Main Office of Mining Studies and Designs/ endeavouring to keep a high standard of technical solutions has been broadly applying for more than ten years a number of computerized methods.

GBSiPG was one of the first designing institutions in Poland which undertook to organize in 1966 its own computer centre. The introduction of electronic computing techniques for design purposes took place already a few years earlier, whereby use was made of different standard programs, mostly derived from the building industry and intended for static calculations of mine surface plants. The creation of the own computing centre, equipped with digital computers and located at the premises of the office, considerably facilitated the application and spread of computerized methods. At the same time, a broad-scale training scheme for designing personnel was initiated. Now our office possesses the computers ODRA 1204 and ODRA 1305 with operational memories 16 K and 64 K, as well as several mini-computers. Due to the specific features characterizing the activities of the office we have worked out own original programs destined to meet the needs of the coal mining industry. More specialized problems are elaborated in co-operation with technical universities and research institutes. For instanco, the problems of organization and managomont of mining enterprises have been solved jointly with the Organization and Management Division of the Polish Academy of Science at Bytom; the methods of surface deformation calculations - with the Institute of Mine Designs and Surface Protection of the Silesian Polytechnic at Gliwice, some selected problems of data processing for management purposes - with the Computer Institute of Mining Industr at Katowice, etc. The whole activities are co-ordinated by the Department of New Technique in the Ministry of Mining.

2. Principles of using computerized methods in mining designs

Computerized methods are applicable at all design stages. In particular these stages embrace:

- programming the dovolopment of the total coal mining industry,
- feasibility studies,
- detailed technical dosigns,
- designers supervision of the designs realization at constructions sites.

The scopes of the different computing programs are adjusted to the different stages of the design process and to the individual nature of particular projects. In collieries whose design is being the basic subject of activities of our office, there appears a close correlation and feedback between the performance of different coal-production sections and the technological processes. Therefore, it would be advisable to consider a mine as being a big system and to examine it comprehensively by means of the methodology of systems analysis. Consequently, it would be possible to achieve an optimum structure and size of the system, which means - of the mine.

The introduction of computerized methods offers such possibility, but the use of optimization methods for some big systems, and especially very complex systems like mines, would pose great difficulties in practical terms, and therefore the application of partial analyses - for individual sub-systems and the search for partially optimum solutions has been adopted, although it is obvious that usually the sum of partial optimum solutions is not the same as the total optimum of the whole system. A yet broader scope of problems appears in designing a new coalfield or coal region.

For the integrated time-and-space interconnection of the mining and regional development such solutions have to be considered and worked out as:

- optimum recovery of coal from deposits and the utilization of accompanying minerals,
- development of a suitable infrastructure for the region including ancillary services, social and living facilities, communication and transportation networks, water supply and sewage disposal systems , power supply, etc.,
- development of associated industries, especially industries traditionally inherent in the region,
- development of schools of different levels and specializations, and creation of adequate jobs for different vocational groups,
- measures for protecting the environment.

A separate problem is the application of data processing for the design and office work. For this purpose a computerized information system has been implemented which collects all information on some selected works carried out in five different regional design offices subordinate to the GBSiPG. A simple system of descriptors provides quick and selective getting of information on the chosen technical problem or design solution. The processing diagram and the structure of the information - and - finding system is shown in Fig. 1.

2.1. Planning the development of the coal mining industry

The design concepts for the development of the industry are conducive to the attainment of techno-economic proposals for decision-taking by the Ministry of Mining and, at the same time, are the basis for drawing up long-term plans. In the planning process use is made of programs with the criterion of economic feasibility of the project. This criterion consists in the minimization of capital expenditures or of production costs. The most frequently used programs are the following ones.

a/ Programs for calculation of natural parameters of deposits

They enable to carry out calculations of coal reserves in the deposit for any ranges of depths and to establish the principal model of a mine, including its subdivision into horizons. The programs are intended for analysing the reserves in prospective areas explored exclusively by boreholes as well as for areas of mining projects for which the degree of accuracy in geological exploration, the indispensable protective pillars, the seam outcrops, the lines of faults and other disturbances, have been determined. The programs include 10 freely selected parameters of the deposit /e.g. ash content, sulphur content, type of coal, calorific vaule, etc./ The programs have been used many times for designing, specially on the new Lublin Coal Region, and for finding proper solutions of such problems as:

dividing the deposit into mining sections, the optimum depth for establishing the mining horizons, location of shafts, etc.

b/ Calculation program for deformations of the rock body and the mining surface

This program allows to forecast the size of deformation indices at different stages of exploitation, to adjust the exploitation influences to the strength of surface objects, and to arrange the exploitation panels in such a way as to minimize the damaging effects upon the surface.

2.2. Feasibility studies on mines

The computerized methods applied at the stage of feasiblity studies allow the conduction of multi-variant techno-economic analyses tailored to the given mining and geologic conditions. To the most frequently utilized programs at this stage belong:

a/ Mathematical model for single-horizon mine

It allows to choose the most favourable layout solution for the underground and surface of a mine according to economic criteria and to prevailing natural conditions. In line with this method, the physical model of the XXX Anniversary Mine in the Rybnik Coal Region was established. The results of calculations permitted to make savings in capital expenditures in the order of 60 mln zlotys.

b/ Optimization program for dimensions of mining areas in collieries

This program was applied, among others for the Lublin Coal Region in order

- to estimate the economic effects related to different dimensions of a mining area and to select the optimum area,

- to compare the effects of different mechanization and automation systems in mining operations,
- to compare the economic effects of different coal production levels from a single longwall face and from a whole mine,
- to compare the effects of different methods of opening and developing the deposit.

The panelling model for one of the mines as a result of optimization calculations entailed the decrease of production costs by about 10 per cent.

2.3. Technical designs

At the stage of preparing technical designs, programs are used for calculations in the scope of constructions and of technologies. Consequently, the designer obtains a number of technical data enabling an enhanced use of available objects, materials and equipment. Several programs applicable at the initial stage of designing, e.g. the program of computing reserves or optimizing the size and structure of a mining area, might also be used at this stage.

The construction and technology programs used most frequently here are as follows:

a/ Software set for static and dynamic calculations with regard to surface and Underground structures

This set includes more than ten computing systems and programs such as

- dynamic calculations of foundation blocks underneath non-percussive machines,
- dynamic calculations of tower structures,
- static and dynamic analyses of flat rod systems and of stocky frames,

- static analysis of construction scaffoldings /for roofs/ and of floating foundations,
- static analysis of spatial systems,
- analysis of foundations and of underground parts of buildings exposed to the influence of mining.

The abovementioned systems and computing programs are based on an own original, theoritical basis which permits to design the mining construction objects with allowance for several interrelations and factors impossible to be introduced without computerized methods.

The implementation of the methods has followed in many mining constructions, such as industrial buildings on the mine surface, supports of underground workings, hoisting vessels, housing and social buildings, and structures of the mining ancillary services.

Parallely to the broad introduction of programs in the coal mining industry, many analyses and computations have been done for design requirements of other industries, such as the steel industry /plants for Katowice Steelworks/, the building industry /housing and communal projects on areas affected by mining/, the health sector /Medical Centre at Ochojec/, machine industry /support structures for boilers/, power generation industry /foundations for high-capacity turbines/.

Economies achieved through the use of the enumerated programs are estimated to amount to about 25 mln zlotys per year.

b/ Programs for computing ventilation networks

They enable to calculate the temperature and the distribution of air - flow in workings with pre-determined cross-section sizes and known characteristics of the main ventilation fans.

c/ Programs for computing the hydraulic stowing system

They lead to the determination of parameters of the stowing installation at the surface and the diameters of the underground stowing pipeline grid.

d/ Optimization program for parameters of a mechanized longwall face

The program gives the width of the longwall face and the length of the longwall panel, the production figures, the face's daily rate of advance and the labour productivity. At the same time it indicates the lowest production costs connected with the given mining and geological conditions and with the selected technical equipment for the longwall face.

e/ Program for computing the main dewatering system

The results of those calculations include parameters of the main dewatering system,such as: the size of the underground water tanks, the required capacity of pumps, the flow velocity thoough pipelines, the thickness and weight of the pipes, the selection of pumps and motors.

f/ Optimization of the main rail and belt-conveyor transport system

By applying a simulation program for the r.o.m. transportation process, the following factors are being optimized:

- the capacities óf the surge bunkers in the mining section and at the shaft bottom,
- the scope of earth-work in the construction of railway lines and roads, as well as in ground levelling operations,
- the geometric schemes of railway stations and of road systems,

- the maximum outflow of atmospheric waters from river basins.

Very often the office has used computing programs for the determination of resistance of hoisting elements such as skips, cages, braking arrangements, and for concession calculations. Other sectors may also use programs for the underground power supply and low voltage power networks, as well as for sanitary and heating installations. For purposes of environmental protection computing programs are used relating to the effects of air pollution caused by heating plants.

2.3. Supervision of designs realization at construction sites

Designers of our office are conducting supervisory works at construction sites according to joint agreements with the investors. Computer programs used in that case are based on network methods enabling to establish the critical path on the construction schedule of the project or of a set of projects. Besides, other analyses are also made on the utilization of basic input materials. This way of leading the investment activities quite frequently allows for shortening the time of construction by some 10 per cent and cutting the lead time preceding the attainment of production objectives.

3. Conclusions

This paper has presented the range of computerized methods application at GBSiPG. These methods are used in design practice both for large projects., such as mining and regional development in connection with exploitation of coal deposits, and for everyday needs in different designing branches. The interdisciplinary approach as applied at the office makes allowance for achievements of theoretical disciplines, for results of research and development acticities and for the experience of engineering practice. The office is stimulating the collaboration of innovators, scientists, designers and economists.

The resultant new ideas and solutions, based frequently on R+D efforts, are constantly introduced through technical designs into investment practice to safeguard the possibly highest standards of performance in Polish mines.

On the basis of ample experience gained for many years, the GBSiPG envisages further development in the application of computerized methods. To this end the own computer centre will be expanded in compliance with the growing range of forthcoming tasks.

Fig. 2 shows an up-dated scheme of organization regarding computerized calculations.

The extension of use of computerized methods is foreseen primarily in the following scopes:

- elaboration of prognoses,
- multi-variant optimization analyses,
- automation of the designing process,
- methods of management and process control on the scale of a mine and of a mining division.

These objectives will be feasible after a subsequent onlorgomont of tho computor contro by now itomo of oquipmont, particulnrly of tho firot poriphory /dioc momorioo, plotting output/ and for tele-transmission of data. This will improve communication with the customers. The implementation of those projects will be supervised by the Department of New Technique in the Ministry of Mining, in close co-operation with the Computer Institute of Mining Industry.

FLOW-CHART OF DATA PROCESSING AND SYSTEM ORGANIZATION OF INFORMATION FINDING AT THE MAIN OFFICE OF MINING STUDIES AND DESIGN (GBSiPG) KATOWICE

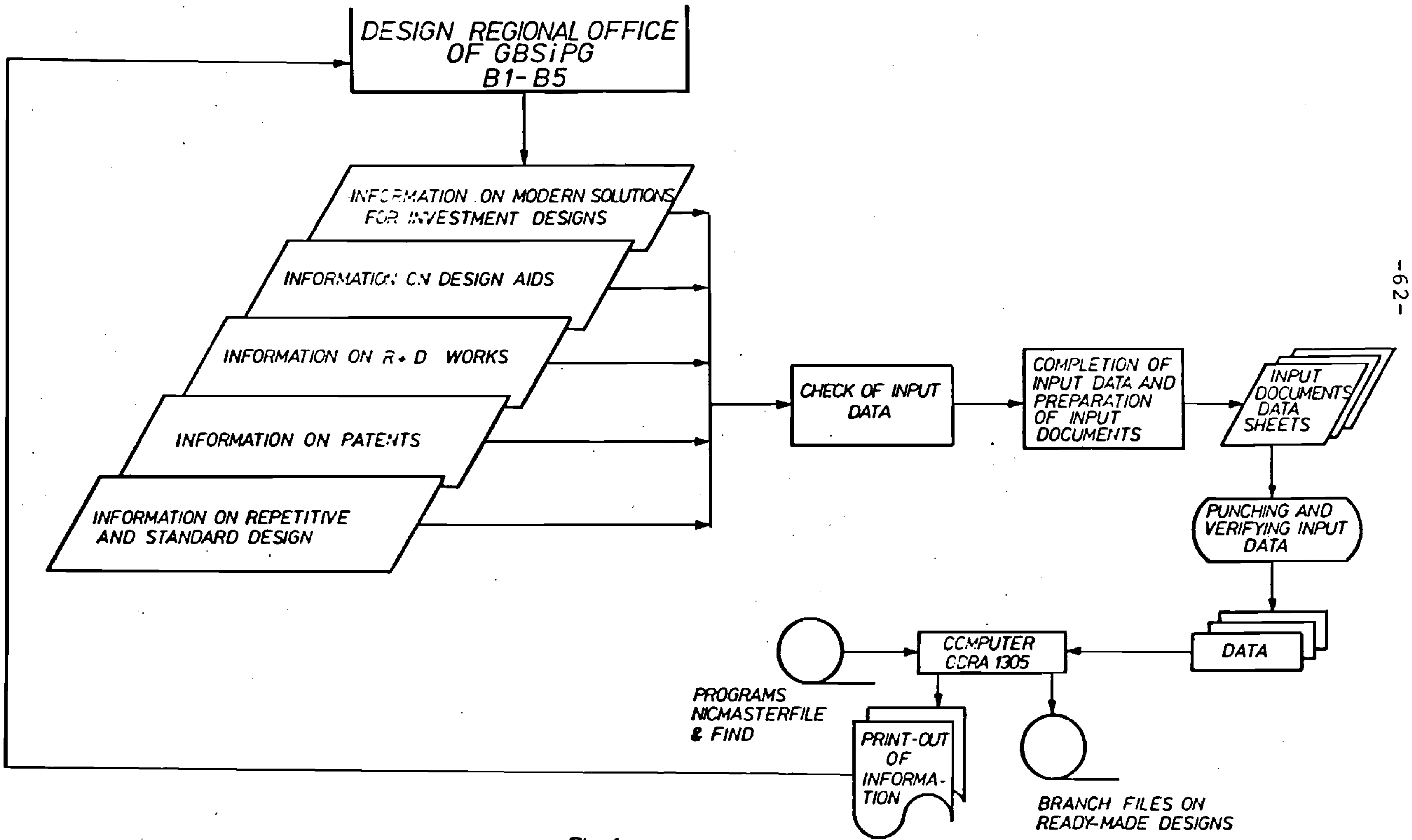

Fig. 1

ORGANIZATION SCHEME FOR COMPUTERIZED CALCULATIONS AT THE MAIN OFFICE OF MINING STUDIES AND DESIGNS

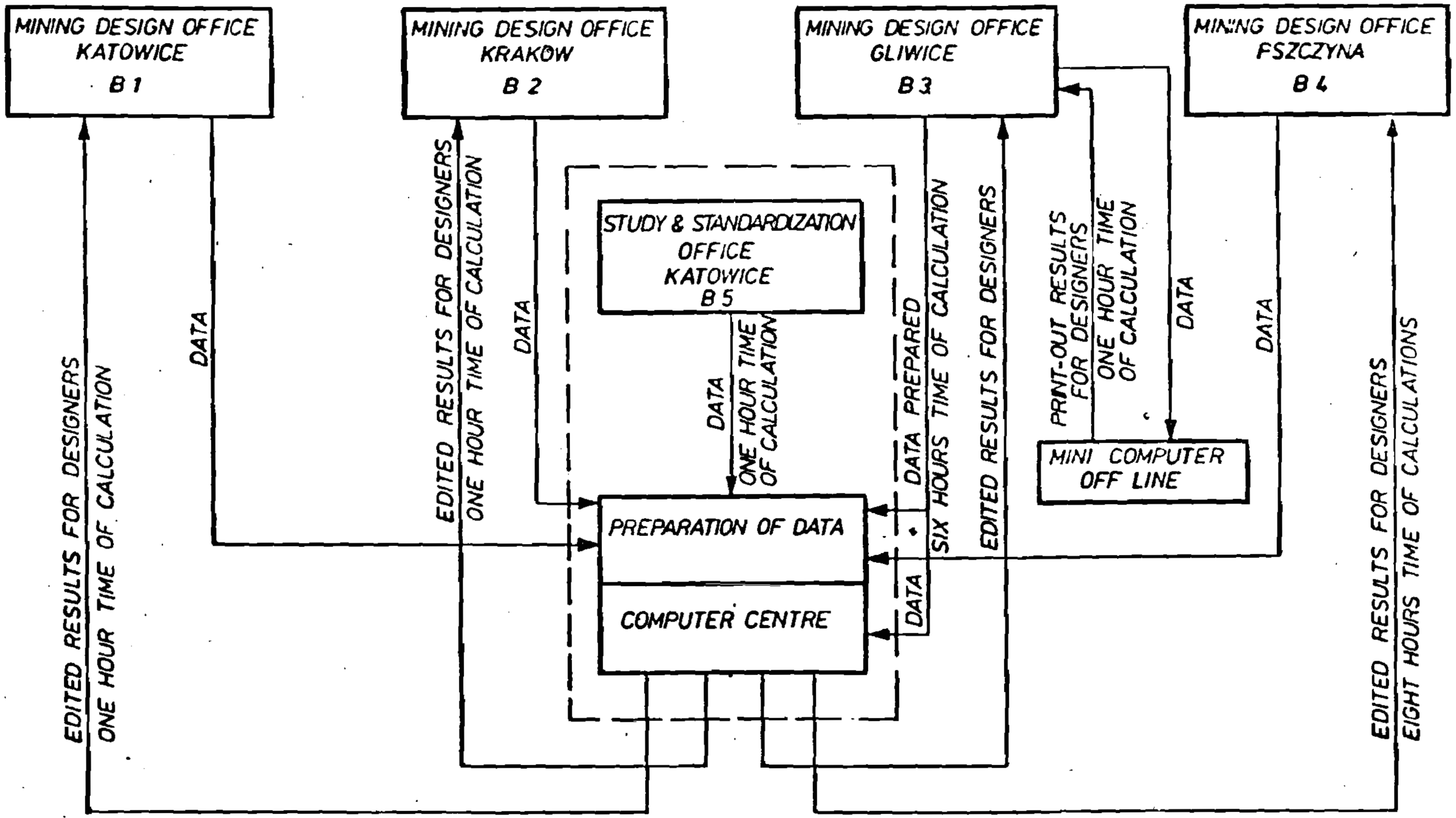

Fig. 2

RESEARCH INTO THE LIKELY EFFECTS OF INTRODUCING LHD EQUIPMENT INTO COAL MINES

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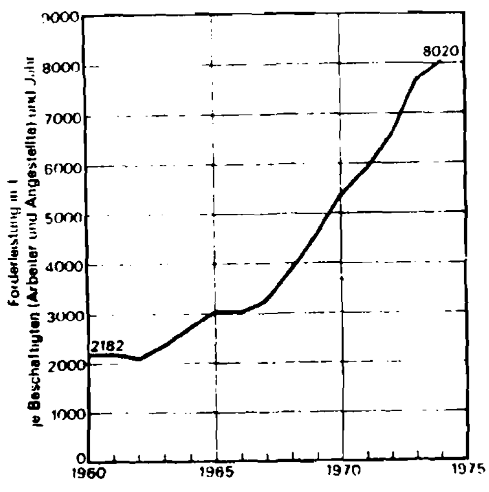
1. Reasons for the research of probable effects by introducing LHD equipment in coalmines

Stimulated by U.S. - american developments "trackless-systems" were introduced to west-german potash- and later on to ore-mines, at first only as LHDs in production and later on - according to the general demands for dieselpowered engines - in all parts of the mine, where high mobility was necessary. Reason for this was mainly the pressure of becoming economically more efficient by overcoming the stagnation in productivity while labour-costs were increasing.

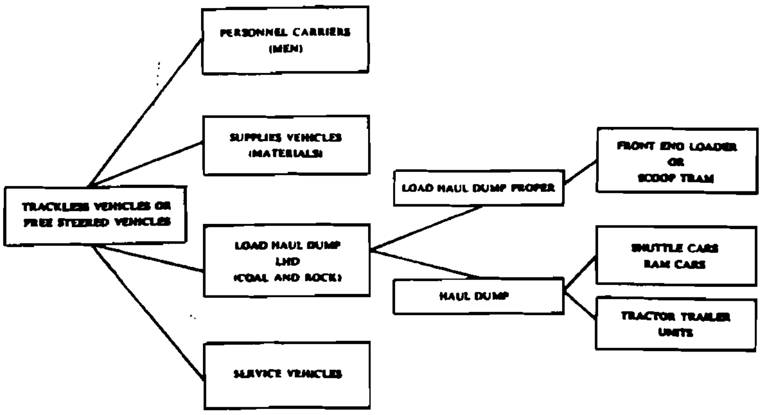
The change to the use of trackless systems implied in most times significant alterations of mining methods and mine development. The fundamental idea wa not only to fit the new systems into existing methods, but also to find new mining methods in order to take advantage of the capacities of the machinery.

Beside the existing machinery used in stoping and tunneling-i.e. scooptrams, drilling-jumbos and blasting equipment - a number of additional dieselpowered machines were developed, which fitted into the LHD-system and lead to further increases in production combined with reduction of staff.



Entwicklung der Untertage-Produktivität seit 1960.

Through this the original Load-Haul-Dump-technique became a part of a system of trackless machines with spreading functions as to be seen on the following diagramm.



Terminology for Trackless Transport

In the early stages of using LHD-techniques in potash- or ore-mines a number of problems arose in connection with operational planning and optimal harmonizing mining methods and development and optimizing the machinery itself.

Therefore, by means of operation research (simulation, queuing techniques, linear programming) interdependances of the new system were analysed to understand the consequences and influences of using trackless machinery underground.

The scope of these studies ranged from single and simple problems, like the evaluation of the optimal distance between transportable crusher-stations in a district to get a most effective combination of scooptrams and dumpers to solve haulage problems up to the research on the optimisation of the entire underground working of potash mines with a daily production rate of 20.000 t/d.

Results of these studies were that trackless systems in underground workings are to describe by methods of O.R. and that the use of computers for research of the technical and economical results of planning can lead to sufficient predictions of the effects of future developments.

Considering the profound improvements in productivity and economics in other mining industries as a consequence of the development of trackless systems, the question arose, whether a transfer of this technology into coalmines - and especially into westgerman coalmines - is possible or not. Doing this a certain amount of restrictions have to be taken into consideration some of which I would like to outline.

2. Transfer of results from other mining industries to coalmines

2.1 Potash-mining

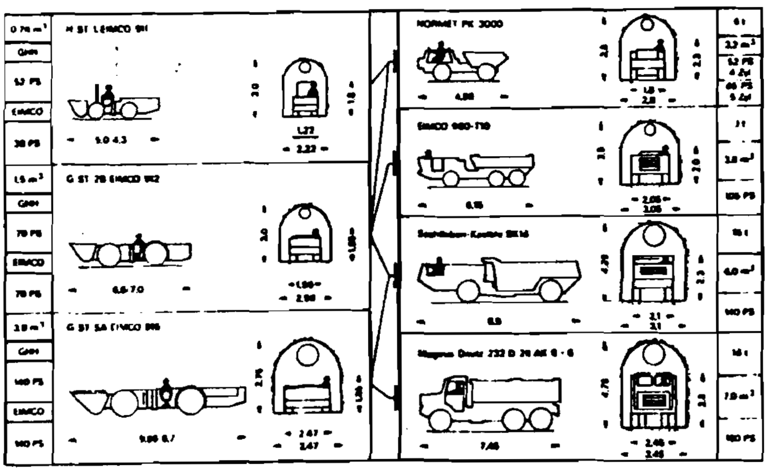
The fast and easy development of LHDs in potash-mines can be explained by the very few technical restrictions:

Due to the rock-mechanical characteristics in potash-mines it is possible to use wide drifts and rooms without support. Therefore nearly every size of LHDs can be used. Combined with that a sufficient stream of fresh air can be provided to dilute the exhaust of diesel-engines. Deposits of thick seams without or with little inclination will not reduce the capacities of the used LHDs. The former use of slushers in "Kammerbau" was abandoned due to the room-and-pillar-method which brought no problems from the rock-mechanical side. The better adaptability of the new method to geological faults improved the output of deposits.

In steep formations and vein-type deposits even more improvements could be reached by using LHDs. Familiar mining methods - like sub-level-stoping - could be improved by using the high mobility of trackless machinery and the inclusion of existing haulage methods - like drop-holes and a central haulage-system on the main-level. Additional development works had to be done for ramps and spirals, but cost-intensive winzes could be abandoned.

2.2 Ore-mining

Ore deposits vary from great masses to steep dipping narrow veins. Therefore LHDs for small drifts had to be developed, and as the capacity - according to smaller payload - went down, sufficient combinations of scooptrams and dumpers had to be found. Some of the possible combinations for different width of drifts can be derived from the following photo.



Further achievements were the possibility of constructing a ramp from the surface to the deposit to avoid the blockade of the main-shaft by hoisting materials and persons. All transport can be done by the ramp.

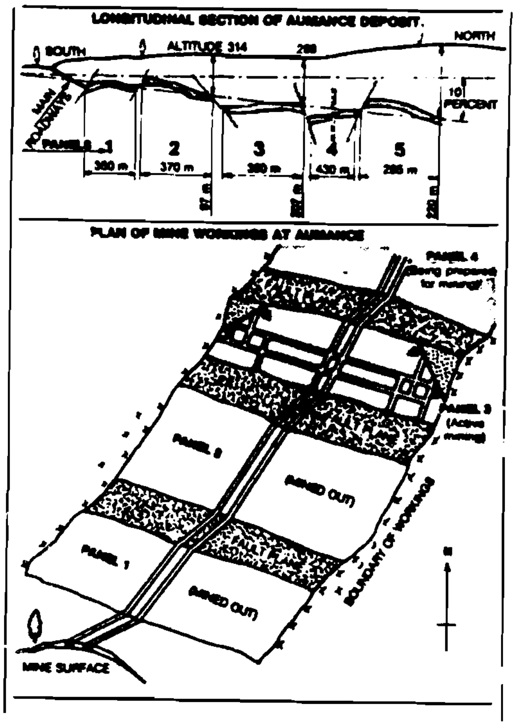
In potash deposits only little roof-support is necessary. By changing to roof-bolting and in our days to a combination of concrete - and roof bolt system a sufficient support fitting into the trackless system could be achieved.

2.3 Coal-mining

From all these descriptions can be derived that the main restrictions for the success of trackless systems underground are

- the type of deposit
- the possible mining method
- the rock mechanics
- the ventilation system.

If there is a coal deposit similar to a seam-type deposit - like the potash-deposits of the Werra-Type - with very little problems of roof-control and a thickness of more than 2 meters, there are little problems to transfer the trackless system into coal-mines as it has been shown at Aumance in France. A 3,6 m seam is mined by a room and pillar method using LHDs. Pit development and face development are very similar to potash mines.



For steeply inclined seams several methods for using LHD-techniques have been developed, using mining methods like sub-level-stoping (RWTH Aachen) or roof and pillar mining (TU Clausthal) with concrete-filling, which were especially developed to fit rock-mechanical and petrochemical demands of coal-mining (roof control, self ignition).

3. Footholds for the research of possible comitmence of LHD-techniques in seam-like deposits level to medium inclinations

The transfer of solutions for LHDs into seam-like coal-deposits - especially in greater depths - is problematic. Due to high pressures none of the known mining methods including the use of LHDs - like room and pillar stoping - can replace the longwall mining, as they will lead to extreme losses of output of the deposit. A continuous mining and haulage system is characteristic for longwall mining and the use of shuttle cars seems to be impossible since the output rate of one face can hardly be managed. Therefore the stoping area must be excluded from all research. Studying the distribution of men-shifts in a coal mine we learn, that the production demands less than 30% of all men-shifts.

Grubenbetrieb unter Tage		MS/100t Grube A	MS/100t B	MS/100t C
Produktivbereich / Abbaubereich / Strebbetrieb	Strebkopf	0,33	0,61	0,42
	Strebfront	1,22	1,12	1,16
	Strebfuß	0,36	0,61	0,53
	Streb allgemein	0,67	1,65	0,96
	1 + 4	2,58	3,99	3,06
Produktivbereich / Abbaubereich	Abbaustreckenvortrieb	0,79	1,32	2,28
	5 + 6	3,37	5,31	5,32
Produktivbereich / Förderung und Transport	In Abbaustrecken	1,38	2,38	2,17
	Im übrigen Grubengebäude	1,56	4,88	2,32
	8 + 9	2,94	7,26	4,49
	7 + 10	6,31	12,57	9,81
Infrastruktur / Unterhaltung	In Abbaustrecken	0,84	0,48	0,42
	Im übrigen Grubengebäude	1,22	0,32	0,87
	12 + 13	2,06	0,80	1,29
Infrastruktur / Vor- und Herrichtungsbereich	Ausrichtung	0,57	0,72	1,61
	Vorrichtung	0,34	0,12	1,43
	Herrichtung	0,33	0,48	0,74
	Raubung	0,65	0,88	0,61
	Sammelbereich des Grubenbetriebes	0,85	6,76	0,70
	15 → 19	2,74	8,96	5,09
	14 + 20	4,80	9,76	6,38
	11 + 21	11,11	22,33	16,19

There are a lot more in the areas "drifting", "maintenance" and "service". The reasons for that are quite easy to understand:

Longwall mining demands a lot of development works and the rock-mechanical stresses on all drifts make a lot of maintenance work necessary.

The fast advance of the working area away from the shaft causes long transport-times for men and material. Main transport-systems in coal-mines are trains or - if possible - belt-systems, which are quite sufficient for the haulage of great masses, but restricted in their adaptability to changing circumstances. Transportation can only be done along a certain route. The modern pit design demands concentrations of only about 30 men at one working area, whereas these areas are mostly far away from each other. Material transport is complicated by the necessity of a number of loading and unloading works until it reaches its destination. For this purpose the use of trackless systems seems to be the best solution. Another possibility for using LHDs in coal mines is drifting. Although full-facers and semi-facers have been sucessfully introduced into coal mines, still about 70% of drifting works is done by the conventional method of drilling and blasting. In spite of intensive efforts to increase the efficiency it could not be reached due to greater dimensions of the drifts which are necessary by rock-mechanical and ventilation means. The introduction of loaders and drilling jumbos could certainly lead to improvements, as could be testified in some mines.

3.1 Former activities and studies

The first dieselpowered trackless vehicles were introduced to german coal mines in the early 60ties. Small vehicles for transport in gate-roads proved to be not sufficient as the construction didn't satiesfy the underground requirements. Besides that, infrastructure didn't fit into the system, as there were nearly no ramps or spirals.

To provide a convincing use of trackless vehicles, essential alternations of the infrastructure of a coal mine must be made, especially if several seams are mined simultaneously. These will be development of ramps and/or spirals, construction of special workshops, no rectangular crossroads, and, as a special problem, the mine ventilation system. For planning it will be necessary to combine several driftings to provide a minimum requirement of vehicles by maximal efficiency.

Research will therefore split up into:

- technical studies (i.e. development of superstructure, engines, tyres, capacities)
- planning of development works (time-charts, mine layout,infra-structure)
- organisation (harmonizing time tables, dispatching vehicles and transportations).

None of these points should be studied in isolation of the other as there will be many combinations necessary.

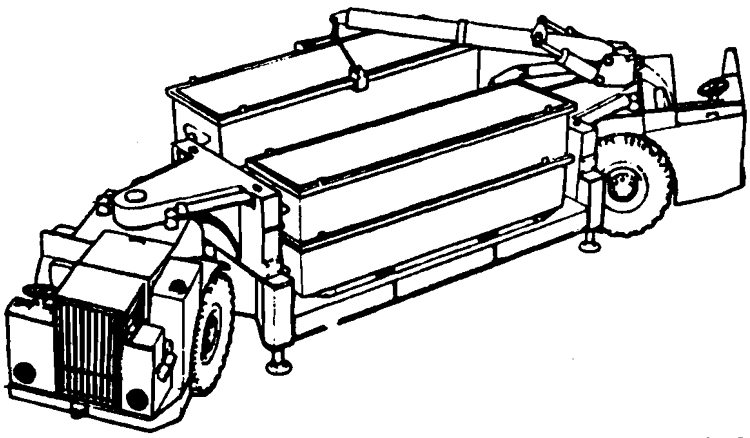
Besides that, at any stage of research comparisons to alternative transport technologies must be made, to prove that trackless systems are still economical. For doing this, several methods are possible:

- for singular, limited problems it will be possible to get a solution "by hand", for instance, for a fundamental study about technical and economical realisation possibilities
- to harmonize the sizes and types of a trackless system vehicles and for capacity studies the use of "simple" programmes on computers using L.P. and queuing theory
- for testing systems and studying the effects of different transportation systems for a whole mine by simulating the underground situation on computers.

Todays development of studies for testing effects of LHD-systems in coal mines in flat seams is still on the first step. First aim is to evaluate possible combinations of vehicles for limited areas and thus to prove the possibility of a technical and economical realisation.

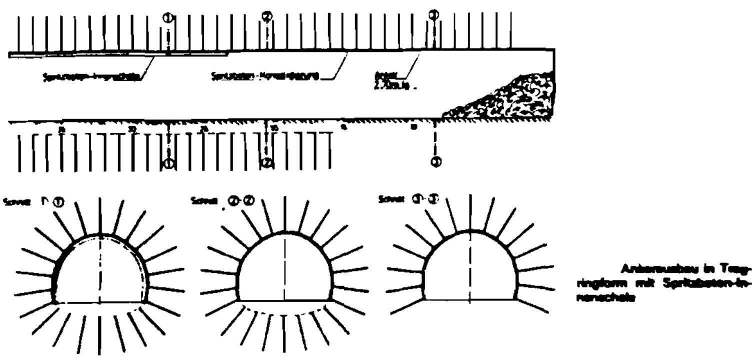
Some studies have brought up the main problems:

- if there is no major change in mine layout, it will not be possible to use dieselpowered trackless systems in coal mines mainly by restrictions of the mine ventilation system. German mine inspectorate demands at least 6 m^3/hp min of fresh air to give a safe dilution of exhaust gases. Therefore the concentration of vehicles in a certain drift must be reduced to a minimum
- especially transport-vehicles must be convertible for being used as personnel transportes and -during the rest of a shift - as material transportes to provide high effeciency.
  The following slide shows one possible solution



Materialtransportfahrzeug für den Steinkohlenbergbau (TA — A 10 (S) der GHH Sterkrade AG).

- practical tests have to be carried out to prove that the bolting and concreting the drifts instead of using conventional frame support is possible. First results are available



The studies have shown, that the use of trackless systems for transport and drifting will be more economic than alternative transport technologies under certain circumstances. Thus the future studies have to show ways to integrate trackless systems into deep coal mines which help to take the advantages of the system and avoid the problems.

4. Future studies

Generally, there will be two main subjects of studies:

- mechanical developments with the aim of making sure that mechanical systems correspond with the requests of coal mines and the restrictions of the mine inspectorate
- Research on operational planning and methods of developing optimal pit design for use of trackless vehicles.

Both directions of studies should be combined to avoid non-realistic modifications in each.

4.1 Methods for research into operational effects

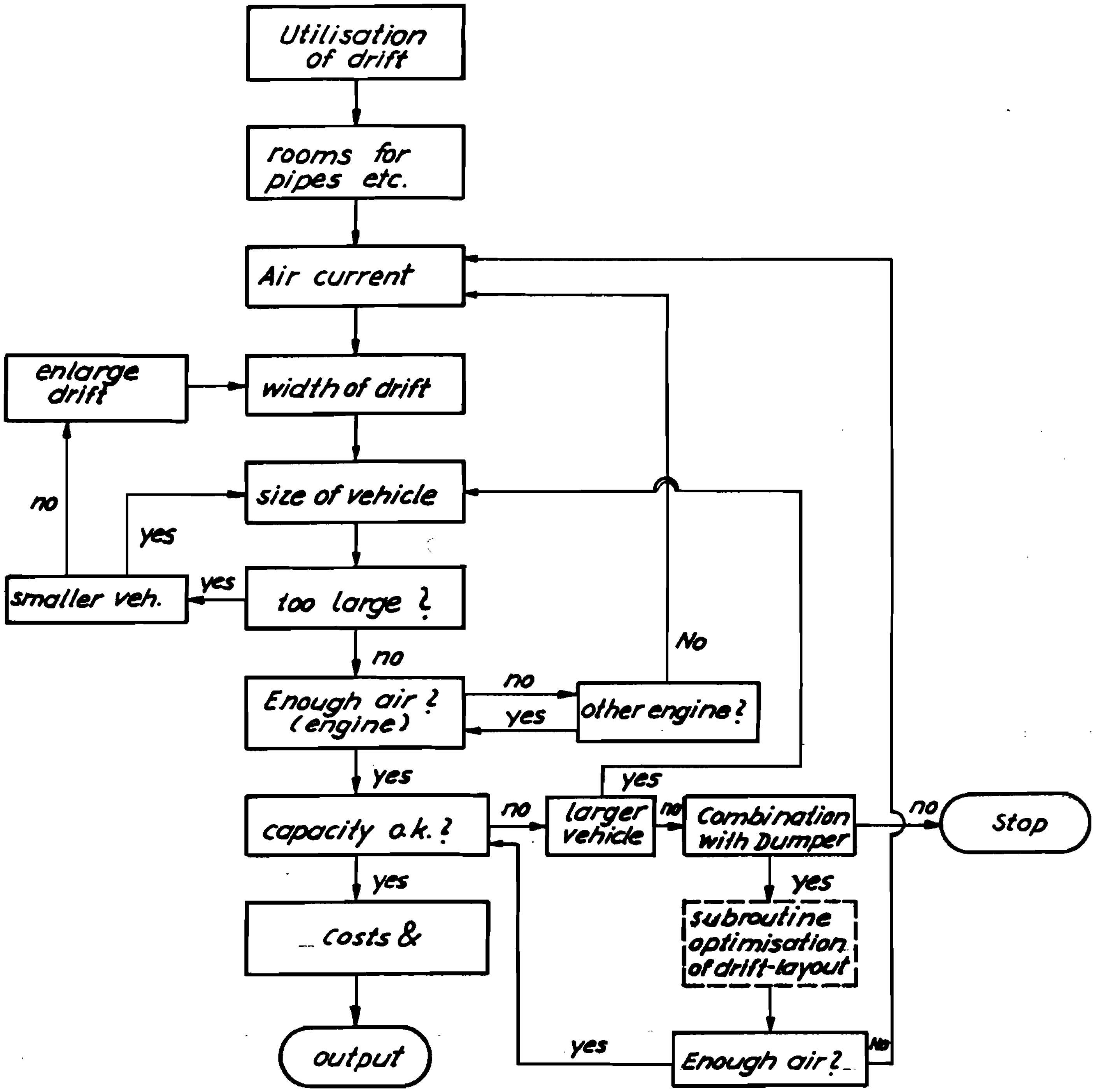
Former simulation models developed for coal mines such as simulation of the underground workings (SIGUT) or Belt and Bunker simulation((BABUSIM) i.e. simulation of underground haulage systems) have proved, that the model-technique by simulation of workings on computers leads to quite sufficient statements about the behaviour of a system.

The simulation of transport and haulage problems by transferring them into a symbolic, mathematical system and calculating this on computers allows an evaluation of probable effects of a lot of alternative solutions. The possibility of a "pre-election" of a few semi-optimal combinations of systems will help to minimize the cost for technical developments.

For the evaluation of a simulation model for computer a number of requests can be given, such as:

It should be possible

- to study the effects of possible technical modifications of trackless vehicles on the underground workings, especially the layout of the mine, in order to reduce the technical development and the need for practical tests to a minimum
- to give optimal strategies for layout and use of alternative transport and haulage systems by simulating variations of the number and types (capacities) of vehicles and the evaluation of alternative organisation systems to an existing or future mine
- to examine the results of the use of different haulage and transport systems in an existing pit and thus give hints for the optimal layout of future pits
- to find "bottle-necks" in systems and to develop methods to avoid them and
- to find and evaluate possible methods of reducing costs in underground workings.



FLOW-SHEET FOR EVALUATING DRIFT-WIDTH AND VEHICLE SIZE

4.3 Some dispositions for a simulation model

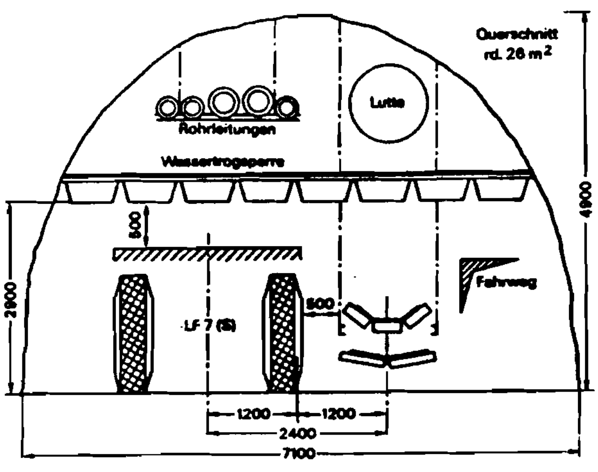
Considering these requests a number of dispositions for a simulation model can be given.

The first step is to develop a kind of flow-sheet for estimating the material flow in underground workings. The aim is to check, how much material has to be transported to which points in what distance at what time, thus to evaluate the necessary number of transport units. Main restriction will be the need of fresh air for dilution of exhaust gases, but also the width of the drifts.

From this data can be derived what will happen if you change the capacity, the speed or the engine power etc.

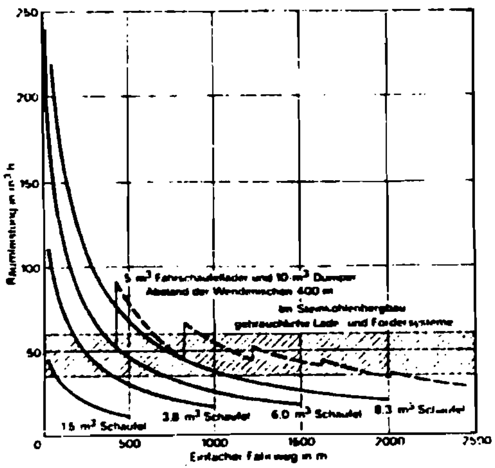
One of the main problems is to evaluate the optimum width of the drifts. The following diagramm shows the relation of some influences:

The minimum width of a drift is roughly given by its utilisation and the amount of air to pass through. Considering requests of low ventilation costs, a wider drift is better as it will have a better resistance characteristic. Furthermore, rock-pressures must be considered to find out the future convergence of the drift. If the size of the vehicles suits for the drift, consider whether there is enough ventilation for the engine.

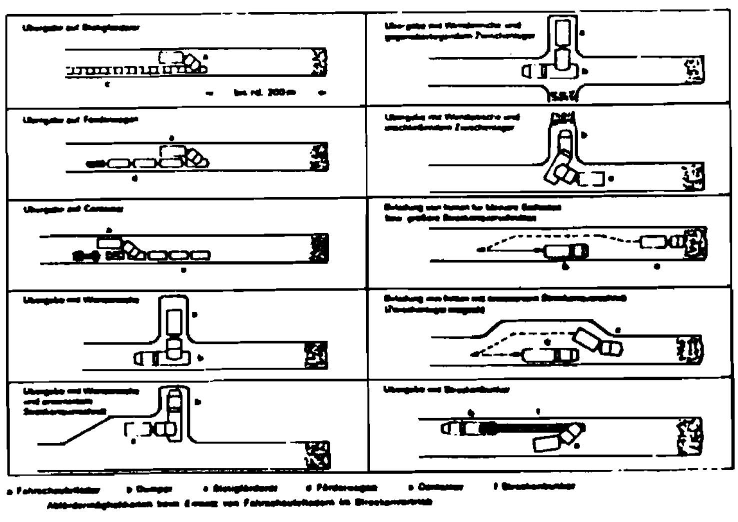


Fahrlader LF 7 (S) in einer Strecke mit rund 28 m² Querschnitt und eingebauter Bandanlage.

If there is not, either a less powerful engine must be used - which leads to less capacity of the vehicles - or the ventilation must be improved, which may lead to a wider drift. If the last solution shall be excluded, the problem is to find out what effect smaller units will have to the underground workings. A suggestion of the problem may be derived from the photo, which shows the capacity of LHDs with different bucket-sizes depending on the haulage length. A combination of a loader and a dumper proves to be more efficient, but then a number of configurations for loading the dumper must be considered.



Räumleistung verschiedener Fahrschaufellader in Abhängigkeit von der Länge des Förderweges.



All organisation must be checked and converted. This can be done by using a simulation model. The problem is, that simulation will not lead automatically to an optimum but any sub-optimal stage. To avoid that it might be necessary to use other O.R.-techniques in combination to simulation.

5. Summary

These statements should give some hints to the aims and ways of research into the effects of LHD-equipment in coal mines. Due to the complexity of the subject some aspects could not be shown as it may be necessary but at least I hope I could give you a general view of the studies going on.

ORGANIZATION AND MANAGEMENT PROBLEMS
IN THE POLISH COAL MINING
Present State of Investigation

J. Bendkowski
J. Stachowicz
A. Straszak
W. Sitko

1. Introduction

In the recapitulation of the March IIASA's task force meeting on the subject of "Coal Issues for the Eighties" it has been stated that "the problems of organization progress in the coal mining will determine the basic conditions of the coal mining development in the eighties".

The importance of the organization problems in the coal mining is determined by the gap between the achieved technical progress in this industry and the organization solutions used. This gap is deepened by such factors as: changeable amount of people willing to work in coal mines and the market structure of fuels in the world.

During this meeting it has been assumed that the problem of management organization and economics of the coal mining will be an especially important element of the IIASA research study.

On the March meeting Poland has presented a paper in which, among other things, we have expressed our opinion on the basic thesis and objectives as well as research methods within the IIASA study on the "Organization and management in the coal mining industry".

In our proposal we have assumed two parallel trends of work. The first one concerns the elaboration of common methodological approach for creating a plane for experience exchange and the results of works concerning the mentioned subject - matter.

The second trend deals with a suggestion of elaborating an uniform methodology of different research works within the study and design of the management organization in the coal mining in different countries. Furthermore, a method of dispersed studies in different countries within the case study and field study accomplished according to a uniform methodology has been assumed.

Accepting the dispersed research works ie. carrying on studie of different detailed problems, work hypothesis etc. in differe countries, the realities of differentiated needs of countries which accede to cooperate within IIASA study have also been taken into consideration.

Whereas, acceptance of the case study method is imposed by the statement according to which the best cooperation effects can be achieved by solving specific and useful problems that are proved in practice.

Since March, the IIASA works, within the problems concerning the organization and management in the coal mining, have been concentrated on the formulation of the initial thesis for developing the studies within the two trends. While conducting the works the following problem groups arose:

I. The actual state of organization and management theory characterized by diversification of different schools and trends which apart from the shortcomings reflecting the present underdevelopment of the organization theory accompli quite often the apological and political goals. It represen an essential obstacle both in the exchange of experiences and research results as well as in preparing and proceeding with works in the international nature.

II. Differentiated socio-political systems as well as the levels of mining enterprise arrangement and the differentiated legal - formal systems in various countries have essential influence on detailed organization solution.

III. Differentiation and uncompatibility of concepts, categories and definitions in different countries is an essential obstacle to scientific cooperation in the field of the organization and management sciences.
It applies not only to the concepts and definitions used in theory, but first of all to categories used in coupling the theory with practice.

IV. Specific features of organizing techniques and computer science solutions result in the shortage of detailed and deep analyses of utility and efficiency of their practical application.

During the application of organization and computer science solutions changes occur both in the techniques and the range of their usage. This makes the elaboration of effective method for utility evaluation of this solutions difficult.

In the next section of this paper we will describe briefly the essential, in our point of view, conditions of these difficulty groups - problems and our proposals of their solution. In our opinion, the above mentioned problems should be a matter of our discussion during this meeting as well as a subject of works developed at IIASA.

In scope of problems described in point I our affirmative opinion on the experience exchange in the field of study and design of management systems share with the majority of research workers opinion who are an authority on this matter. /G.Gwiszani/. Whereas our works concerning problems of the second group ie. difficulties caused by diffirentiation of socio-political, organization and formal systems dealt with the following:

- the choice of approach and research techniques as against the differentiated opinions and the importance of factors forming the management system in an organization,
- the choice of management level, ie. deciding whether our works accomplished within different partial studies will refer to mine section, industrial union, or branch, for example,
- acceptance of some common nomenclature of organization names which function on different management levels in the economic activity,
- the choice of defined phases of the mining activity, ie. deciding whether our common works will deal mainly with the process of deposit prospecting exploration, designing, production activity, transport and investment utilization.

Moreover, we have to consider whether within these phases our solutions will concentrate on the basic production processes or the service and auxiliary ones as well,

- the choice of particularly important problems and matters in scope of the management system which can be solved by the international cooperation.

We have to decide what subject, management level and production process phases in coal mining should be the main task of IIASA's studies.

Our proposal in this scope is the following:

1/ To adopt as a basic method of work, which combines the main advantages, the so called system and contingency approaches. Besides, in our opinion, it is advisable for the synthesis and scientific generalization the usage of the SICT conception which has been formulated at IIASA.

The aim of this concept is to improve the strategy of technical progress control in the context of the organization and social progress conditions. After introducing some necessary supplements /on which we are actually working/ this concept may be very useful in formulating the general principles of the economic system development.

2/ To limit the considerations on the preliminary stage of works to the production activity and to the colliery level.

3/ To put the work plan in three parallel trends, namely:

a/ developing the works for elaborating the study methods, comparing and designing the management organization systems at the colliery level in the context of technical progress conditions in the mining industry and taking into account the specific features of the mining activity.

b/ undertaking the works on the improvement of the ways of experience exchange in the scope of organization solutions and especially such ones as the computer systems which support the management of a colliery /based on the data bank technology and on the usage of microprocessors and microcomputers/.

c/ elaborating methods for intensification of current experience exchange as well as the work results in the scope of management organization and computer science in the mining industry.

Within the third group of problems we suggest to get into touch with the International Institute for Management Problems in Moscow as well as the group of research workers from Hungary and France working on similar subject-matter.

2. <u>Justification of the assumed studies concept. Theoretical situation approach and the developed SIOT - as a basis for the conducted research works.</u>

Among many present trends and schools of management organization theory two are worthy of notice: the system and contingency approaches.

The ideas of the system school and the results obtained while using the elaborated within its framework methods and techniques have been widely described in literature. Whereas the contingency approach is comparatively a new

approach introduced to studies and design of management organization. It makes the assumptions of differentiated environment influence on different economic systems which in turn cause the creation of different organization structures, styles of control and the differentiation of organization climate etc.
Authors presenting this approach recommend to study the management as a defined organization in the context of individual /situation/ conditions and factors of its development.
This approach is characterized by great empiricism and has many advantages.
The research workers lay a stress on the practical aspects of the organization study and design. Besides this approach facilitates the analysis of a defined organization as an individual system.
Within this approach many studies have been undertaken. The results of these studies contribute greatly to the organization theory only to mention the works of J.Woodward, T.Burns, G.M.Stalker, P.Lawrence, J.Lorsch and the works of K.Doktór's group /Poland/ and others.

As it already has been said the study trends creating the present state of organization and management theory formed mainly in the USA have apart from its scientific value defined political and apological goals.
That is why their transfer to the planning economy conditions of establishments in the socialistic countries calls for critical analysis.

G.Gwiszani has made a very detailed appraisal and critical estimation of those approaches assuming as a base of estimation the differentiated development conditions and the goals of establishment functioning in the system of market and planned economy. He has also defined the basic principles of transfering the achievements of those approaches into the management organization theory and practice in the socialistic countries.

Very interesting is the conception proposed by Mr.P.Khandwalla. It deals with the simultaneous system and contigency approach or rather the development of the contigency approach by the mathematic modelling techniques and the choice of rational solutions etc. that are characteristic for the system approach. The model and the study methods presented by Mr.P.Khandwalla in his work "Design of Organizations" are very interesting for studying the management organization at coal mines. Basing on the approach which includes those two schools he has conducted studies in 103 Canadian firms and in 79 American ones.

The obtained results and especially those concerning the practical recommendations and the techniques of management and organization design on the establishment level caused that a group of specialist from Polish research institutes and from IIASA took an interest in the study methods used by P.Khandwalla.

We have considered the concept of developing the methods used by the author for the purpose of the comparative analysis of coal mines. Up to now we have elaborated, together with the IIASA specialists, a preliminary version of questionnaire for describing the coal mine making allowances for the variables which characterize the management system of a colliery.

The next element in the conception of our studies is the assumption and development of a specific methodological base so called SIOT.

As it already has been said this concept was developed at IIASA and accepted as a methodological base for the purpose of improving the strategy of technical progress control in the aspect of organization progress conditions and changes of staff qualifications, management style, motivations etc.

Developing this concept and especially adopting it for the purpose of organization study by means of management of a specific economic system, a colliery, for example, and basing on the contigency approach we have developed a model for organization study, which we have called "the developed SIOT". In this model /fig.1/ we have assumed that each organization /a colliery/ is characterized by specific variables that distinguish it from the environment.

The basic specific variables of an organization are the following:

- the structure of organization goals which especially take into account the relation of social goals of an organizati to its individual goals,
- human knowledge and the relations occurring betweeen its elements cumulated in the system,

- relation system between the knowledge media as well as the relation between the knowledge media and the organization environment.

1. The structure of organization goals.

Different organizations have differentiated structures and goals. The differences are especially noticeable in the mutual relations between the individual system goals, profit etc. and the social goals, which are measured by a ratio of social cost of functioning and development of organization to the social profit that is elaborated in it.

It is very important to consider the "success" of an establishment in two goal categories.
The structure of system goals is a base of the system development appraisal.

2. Cumulated in the system human knowledge and the relations occurring between its elements.

Seemingly similar production plants in point of equipment, technology used, the applied production organization, similar staff structure etc. achieve different results. It betrays the specific quantity and quantity characteristics of cumulated in them knowledge.
We assume as a base of classification of this knowledge a differentiation of subsystems creating a defined economic organization. The subsystems are: technological, social and organization, the relation between the social system and the others as well as between the environment and the relations within the social system which are: the technological, socio-technical, economic, organization legal, and ergonomy knowledge.

According to the assumed definition we will describe the technological knowledge as a reflection of goal relations system which occur between the material elements and energy. This relation system creates instrumentation /devices,tools etc/ and a dynamic string of proper events-defining eg. a technological string.

The organization knowledge represents the system of relations which occur between the work processes reserves both the production processes and the information-control which appears in the directives of efficient action and their usage what leads to the increase of system synergy.

Great part of the system knowledge, especially the technological one has been materialized into isomorphic schemes i.e. into instrumentation and its goal strings /technological strings/ - hardware.

Part of the "Knowledge" especially the organization and economic one is projected into homomorphic schemes /organization structure of an establishment, standards instructions, scope of activity etc./ - orgware.

The remained part appears in a classical form of knowledge and remains in the mind of the participants of work processes - software.

It has been assumed to call this knowledge hardware, orgware and software, respectively.

Such a differentiation is in our opinion purposeful for creating a concept of studying the organization in the aspect of analysis of technical progress dynamics interaction /hardware/ on the organization progress /orgware/ and changes in preferences of men needs their qualifications etc. /software/.

Technical devices, technological strings etc. are called hardware media; organization structure, instructions, standards, formalized procedures etc. are called orgware media and the participants of work processes - staff and managers - software media.

We can assume that the volume of knowledge contained in the system is the function of quantative and qualitative relations between its media.

Undoubtedly the size of software depends on the amount of staff and their qualifications, on the managerial staff, orgware volume as well as the volume and quality of the formalized relations and procedures creating the production organization and management organization. It concerns all the more the quantity and quality of machinery and devices. In our opinions, the volume of software, orgware and hardware is an essential feature of the segregated category defining the system.

3. Relation system between the knowledge media and the organization environment.

Each system /organization/ is characterized by specific ratio of included in it potential knowledge to the really used ones. The measure of this ratio is the degree of organized system /organization/, which beeing positively evaluated can be referred to its synergetic effect degree. The system of mutual, collective and qualitative relations between the knowledge media in the system, and first of all, between those media and the environment is a specific feature of an organization which distinguishes them from the environment and allows to talk about the next component of the system size.

The greater the knowledge in the system is, and the greater is the synergetic effect between the relations and the knowledge media, the effect beeing the function of the system compactness, the greater is the system influence on the environment and the system is bigger.

The system /organization/ compactness is shown up in the "precision" of relation between hardware, software and orgware.

We say that the organization is compact if in the mutual relations-hardware, software and orgware there is a lack of supraevent connections.

In the economic organizations of such a type as an establishment, for example, there is a predominance of relations between hardware, software and orgware which are appraised positively.

An assumption of functional, proportional connection of compactness with the synergetic effect is drawn.

The mentioned three variables of a system decide on the measures of the system appraisal are - the system size, its success and development.

At present there are no simultaneous and comparative variants of system evaluation /we have in mind especially the production plant/.

The existing measures eg. production effectiveness /the profit volume, prime costs, productivity etc/, system size /number of employees, production volume, value of fixed assets/ etc. cover indirectly and not identically in meaning and due to this insufficiently comparable relation features between the three distinguished components, specific variables of a system.

In practice, however, we use the qualitative, heuristically determined and understand measures.
We say, for example, that a given system realizes "better or worse" the social goals in irrespectively of the evaluation degree of its own individual goals.

We are able to evaluate in general the system size, its ability of performing defined tasks, the ability of innovation, of taking risk etc.
Having not yet such an approach which would offer a full set of system measures which could characterize entirely its variables for the purpose of our initial works we use a simplified model.
In this model we use the generally used measures of size, effectiveness and the volume of hardware, orgware and software.

Such an approach has been used for determining the effect of mine size on the management capability by its managerial staff.
In the presented model it is a trial of determining the relations between the volume of hardware, orgware and software and the system of the interrelation of those variables and the environment.

3. Results

According to the presented in March detailed research plan and the methodology we have done the following works:

I - literature study in the scope of new approaches and methods concerning the management organization study and design,

II - development of a detailed plan and study schedule,

III - choice of detailed work methods,

IV - conducting the firt part of studies in the scope of recognition some relations between the colliery size and the situational variables which form the management capability.

The studies referred the recognition of some relations between block 1 and 3 as well as 2 and 3 /fig.1/.
The choice of these relations depended on actual possibilities of precise description assumed for variable considerations. The preliminary work results have been presented on the June seminar at IIASA.

V - carrying out the next stage of works in the scope of recognition the structural dependencies between the variables describing the organization structure in collieries.

the presented in March work method we have assumed the lowing procedures:

1. Division of the analysed collieries collection into homogeneous classes. In the set of variables, that we have assumed for the purpose of grouping the collieries we have foreseen the need of taking into account the variables differentiated depending on the environment, differentiated sizes describing the technology of the social system as well as variables describing the organization aspects of the studied collieries.
2. For defined homogeneous groups of collieries which are also characterized by similar degree of organization according to the presented concept and similar compactnes degree between hardware, software and orgware we have proposed to consider the individualized, in respect to given colliery, groups the works designed in the scope of improving the management organization system.
3. We have assumed that the works will be carried out according to prognostic approach i.e. defining for different groups of collieries some ideal /pattern/ variants and adopt them to the actual possibilities defined by the relations hardware, software and orgware.

The presented procedure required some additional works, namely :

a/ carrying out works in the scope of precise description of different variables concerning different media of hardware, software, orgware and the colliery evaluation coefficients;

b/ developing the detailed concept of studies in she scope of block 3 /fig.1/ i.e. defining the concept of its organization structure, compactness in the aspect of hardware software and orgware integration.

c/ defining the essential structural relations described in literature as the organization structure conditions.

We have adopted for the study purpose the concept and method used by K.Doktór research workers group from the previous Institute of Management Organization - Polish Academy of Sciences. At present this concept is an expansion and adoption to our conditions, an approach known in literature as Aston Group method.
The development of this conception and adoption of it to the coal mining required the preparation of special questionnaire. This questionnaire is presented as an enclosure to this paper.

The works that are at present carried out in the coal mining industry are an expansion of K.Doktór's group studies. For example, the structural activity in a colliery is considered according to five basic management functions and analyse the factors facilitating and making difficult the function accomplishment.

The studies that will be carried out according to this questionnaire include all our deep collieries. They also concern the organization structure understood as an arrangement of organization elements /treated according to custom, in a form of so called organization scheme/ and as an arrangement of institutionalized standards of procedure.

- structure size i.e. configuration, centralization, specialization, standardization and formalization size,

- compactness within individual sizes having regard to the three segmental relation: hardware, software and orgware,
- the dependence studies between:
- environment and structure,
- tasks and goals of organization and structure,
- variables describing the quantity and quality of hardware, software and orgware media and the structure.

The studies according to the presented questionnaire have been carried out in five collieries.
Moreover, the method of research results synthesis has been developed.
It includes the following:
- factor analysis,
- statistical methods,
  etc.

We assume that up to the end of the first quarter of 1980 we will carry out studies in all the collieries and we will define the final conclusions in the scope of:
- differentiated compactness of organization structures of collieries,
- their differentiated conditions.

Furthemore, we will conduct a taxonomy of our collieries into homogeneous classes which will consider also the degree of their organization.

VI. Studies on the evaluation of the state and usage of the computer systems implemented in the collieries within the so called computerized management system have also been conducted.

The present development stage of the industrial enterprises - including collieries is charactorized by:

1/ development of enterprise management sphere with clearly defined differentiated computer science - decision processes within which the explicitly formed management functions are accomplished.

2/ distinct increase of knowledge included in all types of its media beeing the reserves which take part in the computer science - decision processes.

Together with the computer science progress a considerable increase of hardware for the management system may be observed.

3/ differentiated and complicated interrelation occurying between hardware, software and orgware for the management sphere. The differentiated and complicated character of relations between hardware, software and orgware management sphere speaks for the fact that up to now the computer science influence on the organization structure and management style has not been yet defined..

4/ The creation of the objective purpose-ful necessity of integrating the management sphere of software, hardware and orgware as an especially essential element of the whole system development.

In the analyses of the computer science solutions usage for the management purpose the mutual non-adjustment of computer systems to the organization structure in which they function and to qualifications as well as patterns of computer systems user behaviour is often emphasized.

That is the reason why thorough studies of computer systems users have been undertaken.

The study included, among other things,:

- defining the direct and indirect users of the information,
- defining the differentiated information needs and factors which bring about the needs,
- defining the factors that influence the individual needs within the formalized system,
- analyses of different user groups in the aspect of differentiated computer science needs etc.

The study has assumed a thesis of system solution unification in the computer science and individual meeting the differentiated needs of the computer users.

The studies have to consider the broad context of the relation set not only between hardware, software and orgware but also the relations 1-3, 2-3, 3 - environment. /fig.1/.

The works of which results are presented in this paper concern a small set of these relations but the main purpose of them was to answer the following questions:

- in what degree do the implemented at collieries systems support the management system?
- what should be done not only in the scope of the future computer solutions in order to make the full usage of the computer systems advantages?

The studies have been carried out in eight coal mines. They concerned 17 computer systems and covered the representatives of all the user groups.

Some results are shown in table 1,2.

Table 1

functions which are facilitated by the computer systems supported at collieries.

Type of function	total /in per cent/
1. Motivation and the action stimulation	27,9
2. planning	53,4
3. Organization	41,8
4. Coordination of the undertaken action	30,2
5. Supervision and control of the undertaken action	39,5
6. None of the mentioned functions from 1 to 5	9,3
7. Data recording	60,4
8. Data processing	30,2
9. Making decisions	37,2
10. Automatic decision making	2,3
11. do not facilitate the preparation of materials for decision making	25,5

Table 2

Statement of respondents appraisals concerning:

1/ colliery goals, which attainment is facilitated by the computer systems,

2/ importance of information for management efficiency.

1. colliery goals	total /in per cent/	2. type of information	total /in per cent/
1.1. main goals	32,5	essential information	27,9
1.2. partial goal	87,3	2.2. essential information	53,4
1.3. no goals	-	2.3. inessential information	13,9

Furthermore many detailed information have been obtained in the scope of the evaluation including shortcomings of particular computer systems that are used at collieries. Many suggestions and comments concerning their improvement were collected.
In scope of this subject - matter our works are concentrated on:

- developing the descriptors catalogue of a colliery.
- preparing the guestionnaire for the comparative studies on the computer science application in different countries,
- preparing the guestionnaire for recognizing the data bases which are created in the management systems in the mining

in different countries.

The XI World Mining Congress in Instanbul and the UNO Coal Seminar at Katowice, the very important meetings of the research workers and practicians, which took place in Poland this year have confirmed the need of developing the universal scientific cooperation in the scope of coal mining, and in such fields as:
organization, management and economics in the mining industry.
IIASA's program and the contribution of Polish research institutes is, in our opinion, a good answer to meet these needs.
The proposed by the Polish research institutes work cycle within the IIASA program concerning the problems of management and organization in the mining industry is accomplished according to the basic plan.
While carrying the works new problems limiting the detailed solutions of the accepted subjects occured.
As it has been presented in this paper we work on those problems as well.
However, we look for close collaboration with other countries in the field of management and organization.
We are sure that the cooperation in this field will develop in the same way as in the problem of technological aspects of the coal mining.

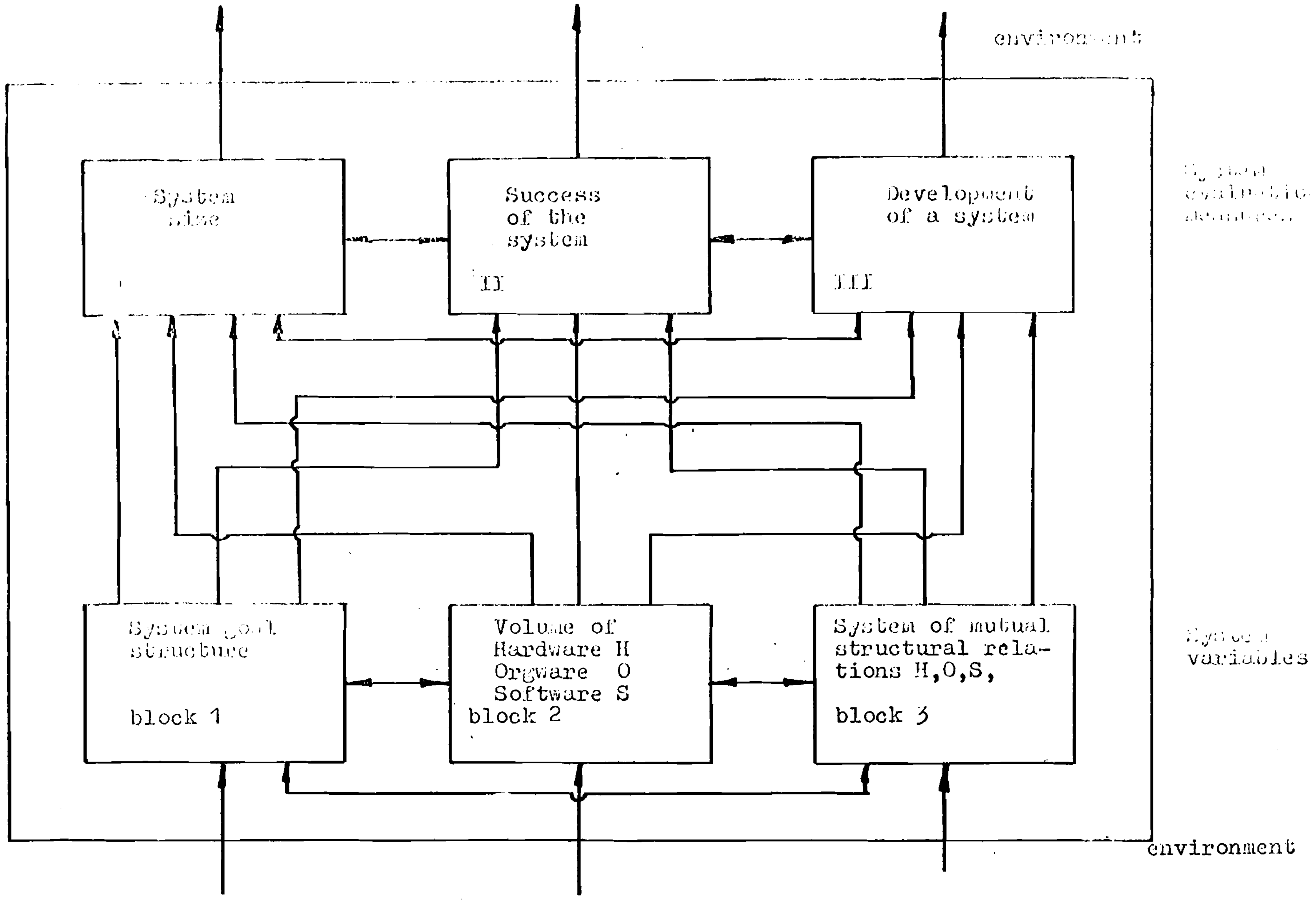


Fig. 1. Model of t... system study

R E F E R E N C E S

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ENCLOSURE 1

COMPUTER INSTITUTE OF THE MINING INDUSTRY

RESEARCH AND DEVELOPMENT CENTRE

KATOWICE - POLAND

QUESTIONARY ON RESEARCH OF THE ORGANISATIONAL STRUCTURES IN HARD COAL MINES

KATOWICE - SEPTEMBER - 1979

COIG-1596-XI.79-30

0. - TECHNICAL CHARACTERISTICS OF THE MINE

1.- Mining area in square kilometer

. . . . km^2

2.- Industrial resources of the mine in thousand tons

. . . .

3.- Mine capacity with regard to the shaft transport in tons/24 hours

. . . .

4.- Number of sections . . . . . .

5.- Number of production levels:

a.- total . . . . .

b.- production levels . . . .

c.- at the final production capacity . . . .

6.- Deepest coal production level . . . .

a.- actual . . . .

b.- final . . . .

7.- Output per one production level

. . . .

8.- Number of access giving shafts per total mining area

. . . .

9.- Number of coal extraction shafts per total mining area

. . . .

10.- Number of hoisting devices:

a.- skips . . . .

b.- cages . . . .

11.- Average depth of shafts

. . . .

12.- Average exploitation depth

. . . .

13.- Average output per one shaft

. . . .

14.- What is the number of staple shafts

. . . .

15.- What is the number of seams:

a.- total . . . .

b.- actually mined . . . . divided into:

- inclined 0 - 10 degrees . . . .

- inclined 11 - 35 degrees . . . .

- inclined 36 - 45 degrees . . . .

- inclined over 45 degrees . . . .

c.- actually mined divided with regard to thickness:

- up to 1 m . . . .

- 1 to 3 m . . . .

- above 3 m . . . .

d.- actually mined with following hazards:

- methane . . . .

- rock bursts . . . .

- dust . . . .

- water . . . .

- gas and rock outbursts . . . .

- self-ignition of seams . . . .

16.- Average thickness of beds in cm

. . . .

17.- Number of main loading points

. . . .

18.- Average distance of loading point from the extraction shaft

. . . .

19.- Coal extraction from one loading point in tons

. . . .

20.- Length of tunnellings:

a.- main tunnellings . . . .

b.- district tunnellings . . . .

21.- Length of transport roads of gotten:

a.- main . . . .

b.- district . . . .

22.- Length of transport roads of materials:

a.- main . . . .

b.- district . . . .

23.- What is the main kind of transport in the mine:

a.- wheel transport . . . .

b.- belt conveyor transport . . . .

c.- mixed transport . . . .

24.- Average concentration upon the underground transport roads in tons/metres

. . . .

25.- Capacity of the Coal Preparation Plant:

a.- at present . . . .

b.- in 1985 . . . .

c.- final . . . .

26.- What is the mining system of the mine:

a.- conventional . . . .

b.- four shifts' . . . .

27.- Number of underground districts in the mine:

a.- total . . . . including:

- production . . . .
- development . . . .
- machine . . . .
- electric . . . .

28.- Coal output per one district in tons:

. . . .

29.- Number of production faces:

total . . . . including production faces with powered supports . . . .

30.- Number of sections with powered supports:

. . . .

31.- Number of shearer-loaders:

a.- longwall type (and coal ploughs) . . . . .

b.- heading type . . . .

32.- Number of conveyors:

a.- heavy duty, scraper type . . . .

b.- light, scraper type . . . .

c.- belt . . . .

33.- Length of exploitation front in metres . . . .

34.- Average output per one production face:

a.- total . . . .

b.- with powered supports . . . .

35.- Percentage output by systems:

a.- caving . . . .

b.- with stowing . . . .

c.- with powered supports . . . .

d.- production jobs . . . .

36.- Average total advancement of the production face:

a.- total . . . .

b.- with powered supports . . . .

37.- Average percentage of contamination in gotten:

. . . .

38.- Total electric power installed underground

. . . .

39.- Average number of employees in the industrial group sub-divided into groups:

a.- production group . . . .

b.- development group . . . .

c.- other mining group . . . .

d.- energetic-machinery group . . . .

e.- remaining group . . . .

40.- Labour consumption in transport - in manshifts/10.000 tons:

a.- gotten . . . .

b.- materials . . . .

41.- Labour consumption in the maintenance of excavations in manshifts/10.000 tons:

. . . .

42.- Labour consumption in the remaining works underground in manshifts/10.000 tons

. . . .

43.- Number of automated links in the production process (by kinds)

. . . .

. . . .

. . . .

. . . .

I. - ORGANIZATIONAL STRUCTURE OF THE MINE

1.- Year of the mine erection

. . . .

2.- Has the mine been;

a.- taken over from a foreign capital,

b.- erected in Poland in interwar period,

c.- erected in the Polish Peoples' Republic.

3.- Has the present mine come to existence as a result of merging with other mines: - YES

- NO

If so, quote when and with what other mines : . . . .

. . . .

4.- Average daily output of coal in tons;

a.- at present . . . .

b.- in 1985 . . . .

c.- final . . . .

5.- Types and classes of coal in the mine in 1978;

a.- types of coal in thousands tons . . . . .

b.- classes of coal in thousand tons . . . .

6.- Value of permanent assets in the mine in millions zlotys as per 1.01.1979

total . . . .

including production means . . . .

7a. Number of employees as per 1.01.1979 (industrial group)

a.- underground . . . .

b.- on the surface . . . .

7.- Number of employees as per 1.01.1979;

total . . . .

including the industrial group . . . .

8.- What number of employees are improving their professional qualifications?

total . . . .

including:

- on post-graduate, doctorate's courses . . . .

- on higher studies of I and II degree . . . .

- in secondary schools . . . .

- in primary vocational training . . . .

- in other training (inclusive courses lasting more than 3 months) . . . .

9.- What is the number of employees as per 1.01.1979:

a.- post-graduate employees . . . .

including engineers . . . .

b.- employees with secondary education . . . .

including technicians . . . .

10.- What is the number of engineers employed as per 1.01.1979 in sub-division into:

a.- those working underground . . . .

b.- those working on the surface . . . .

Note: under working underground are to be understood all those whose daily duty is to go underground. Not included are all those who may occasionally go underground but whose place of work is on the surface.

11.- What is the number of technicians employed as per 1.01.1979 in sub-division into:

a.- those working underground . . . .

b.- those working on the surface . . . .

Note: the meaning of the term "working underground" has been explained by the 10th question above.

12.- How many persons employed in the mine are in charge of teaching in all kinds of schools and training courses:

total. . . . .

including: engineers . . . .

- technicians . . . .

13.- Average value of planned turnover means in 1979

. . . .

14.- What is the mean prime-cost per ton of coal in zloty:

a.- in 1977 . . . .

b.- in 1978 . . . .

c.- in the first half-year of 1979 . . . .

15.- What is the percentage of mechanical coal winning in:

a.- development work . . . .

b.- production work . . . .

16.- What are the main causes of production standstilla in your mine? (please indicate three most essential causes in the sequence of importance):

. . . .

. . . .

. . . .

17.- What is your estimation of the technical condition of:

a.- coal winning machines . . . .

b.- powered supports . . . .

c.- remaining equipment underground . . . .

<u>Note</u>: please use the following denotations: "satisfactory", "almost satisfactory", "unsatisfactory".

<u>Note</u>: if denotation "unsatisfactory" has been used, please indicate at least two causes of such a condition.

. . . .

. . . .

18.- By using an evaluation scale by points from 1 to 7, indicate how you evaluate the technological level of the basic production processes:

a.- basic . . . .

b.- auxiliary . . . .

c.- development . . . .

d.- servicing . . . .

19.- By using an evaluation scale by points from 1 to 7, indicate how you evaluate the production capability of the mine in the aspect of:

a.- the mine's planned tasks . . . .

b.- the condition of machinery and equipment. . . . .(number and quality)

c.- the organization of work processes . . . .

d.- the condition of employees . . . .(number and qualifications)

20.- By using an evaluation scale by points from 1 to 7, indicate how you evaluate the co-relations in the technological processes of the following elements:

a.- number and quality of technical equipment used in the technology applied . . . .

b.- number and quality of technical equipment used in the production organization . . . .

c.- technology and technical equipment applied in relation to the number and qualifications of the employees in the given working process . . . .

d.- number and qualifications of the employees in the given process in relation to the applied production organization . . . .

21.- Are there coal dumping grounds existing at the mine (indicate capacity in thos. tons). . . . .

22.- Does the localization of the mine allow for arranging new (or enlarging existing) dumping grounds (indicate in thos. tons). . . . .

23.- Having knowledge of the documented resources of the mine indicate whether the mine is:

a.- an expansionable one

b.- a stabilized one

c.- one of decaying resources

24.- If the mine is an expansionable please indicate in what in your opinion directions should the technology process be realized:

a.- basic . . . .

. . . .

b.- auxiliary . . . .

. . . .

c.- development . . . .

. . . .

d.- servicing . . . .

. . . .

25.- What is the influence of the mine management onto the actual organizational structure:

a.- no influence at all

b.- there has been an opinion given to the project design by the mine management (the project design itself has been elaborated beyond the mine).

c.- the management has been taking part in the project design work (the project design has been elaborated together with someone from beyond the mine).

d.- the structure has come to existence from a project-design elaborated by the mine's management and is under permanent modification according to requirements

e.- other (indicate the kind of influence) . . . .
. . . .

26.- What is your evaluation of this organizational structure:

a.- the structure is adequate for the requirements and specification of the mine,

b.- the structure is not flexible,

c.- the structure is adequate but the proportions between the rights and duties and the responsibility of managing personnel of the mine are unequally established by the superior management,

d.- other (indicate which one) . . . .

. . . .

27.- Indicate percentage of share of the mine's management in the realization of the basic management functions:

	development	production	manpower	financial policy
Planning				
Organising				
Co-ordinating				
Motivating				
Controlling				

28.- Is the cooperation of the mine's management sufficient in the realization of the basic management functions for the materialization of the principal aims of the mine?

a.- YES

b.- NO

29.- If the cooperation is insufficient, how should it be in your opinion?

	development	production	manpower	financial policy
Planning				
Organising				
Co-ordinating				
Motivating				
Controlling				

30.- How averagely is utilised your working time in the mine and for the mine. How much of your time of a day take the functions listed as an example below (other functions can also be indicated or those listed can be extended). Indicate time basing upon longer observations:

a.- correspondence . . . .

b.- telephone calls . . . .

c.- discussions with subjects . . . .

d.- discussions with superiors . . . .

e.- discussions with party officials, social, trade-union officials and others (e.g. delegations etc.) . . . .

f.- observing the work of others . . . .

g.- executing orders of superiors and others . . . .
h.- travel and waiting time . . . .
i.- receptions of employees . . . .
j.- own planning and organizational work . . . .
k.- briefings and internal confer-ences . . . .
l.- briefings and conferences beyond the mine . . . .
m.- others . . . .
. . . .
. . . .

31.- What kind of technical and organizational office-work equipment is used by yourself and your secretary in your daily work:

. . . .

. . . .

. . . .

32.- Are computerized information systems <u>directly</u> helpful to yourself or your deputy in the mine management:

a.- YES. The following are to be included: . . . .

. . . .

. . . .

b.- NO. (indicate why not) . . . .

. . . .

. . . .

33.- By using a point type evaluation scale from 1 to 7 indicate how you evaluate the mine's efforts to protect the natural environment: . . . .

. . . .

34.- What is the number of departments and posts formally sub-ordinated <u>directly</u> to the mine's managing director (as per 30.06.1979)

. . . .

35.- What is the average number of workers per one engineer underground (as per 30.06.1979)

. . . .

36.- What is the average number of workers per one engineer in the whole mine (as per 30.06.1979)

. . . .

37.- What is the number of organizational departments and independent posts in the mine (as per 30.06.1979)

. . . .

38.- What is the number of exploitation districts in the mine (as per 30.06.1979)

. . . .

39.- What are the criteria for the evaluation of the mine's activity (indicate 5 most important in sequence according to importance):

a.- . . . .

b.- . . . .

c.- . . . .

d.- . . . .

e.- . . . .

40.- Indicate value in thos. zloty of proposals for improvements implemented in 1978

. . . .

41.- What was the "absence index" during 1978 (without hollidays)

. . . .

42.- What number of persons have started work in the mine in 1978

. . . .

43.- What number of people have been released from the mine in 1978

. . . .

44.- What was the number of complaints brought before the mine's managing director, registered during 1978

. . . .

45.- Has the mine already introduced the 4-shifts' system of work?

a.- YES, from . . . .

b.- NO, it will be introduced from . . . .

46.- If the mine is already working in a 4-shifts' system of work indicate how many complaints directly concerning the introduction of that system have been brought before the mine's managing director:

. . . .

47.- How is your evaluation of the efficiency of mine's management considered in the aspect of 5 functions of management i.e.:

a.- planning - which also includes the notion of prediction as well as includes choice between many alternatives,

b.- organizing- which embraces: indication of functions necessary for achieving the mine's aims, their grouping and admission to the managers of indispensable rights,

c.- employee's policy - which is composed of: making selection, placing, promoting and training of personnel,

d.- motivating- which ser es the purpose of inducing the subordinates for prompt execution of their tasks.

e.- controlling - which serves the purpose of checking-up whether the activity is in accordance with the plan and the predetermined target.

Pos.	Activity of the mine	FUNCTIONS OF MANAGEMENT				
		Planning	Organizing	Employees	Motivating	Controlling
		3.- considerable attendance of the mine's managing director in the works carried out 4.- medium attendance which however allows for general knowledge of problems 1.-minimum attendance, fragmentary, sporadic 0.- lack of attendance, the director's attendance in works is not necessary				
1.	Research and development in the mine i.e.: a.-searching for new technologies, b.-introduction of achievements resulting from scientific-technical progress, c.-searching for new solutions, within the scope of new machines and equipment, d.-introduction of new solutions within the scope of automatization, e.-carrying research work in the field of computerization, f.-searching for new organizational solutions and improvements, g.-cooperation with the scientific-technical research centres	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0
2.	Preparation of production, i.e. a.-selection of technology, equipment and organization for new mining faces, b.-establishing of mining fronts	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0

c.- establishing of the production capacity, d.- job standardization, e.- time study and methods of work					
3. Preparation of production, i.e. a.- selection of technology, equipment and organization for new mining faces, b.- establishing of mining fronts, c.- establishing of the production capacity d.- job standardization, e.- time study and methods of work	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0
4. Exploitation, i.e. a.- carrying out exploitation works, b.- transport of gotten underground, c.- transport of materials underground, d.- coal preparation e.- coal quality inspection, f.- forwarding and sale,	3 2 1. 0	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0
5. Keeping up the operation, i.e. a.- maintenance of machines and equipment, b.- repairs and running overhauls, c.- general overhauls, d.- renting of machines and equipment, e.- energy management, f.- underground communication					
6. Store and supply economy i.e. a.- spares b.- machines and equipment c.- protective clothing d.- reserves e.- inventary activity	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0

7.	Economic planning, i.e. a.- long-term planning b.- tactic planning c.- operative planning	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0
8.	Manpower management, i.e. a.- recruiting and selection of employees b.- training and improving the employees c.- training and improving the reserve of supervisory staff d.- bonuses and rewards for the supervisory staff e.- Promoting and distinguishing the employees f.- recruiting and periodical evaluation of the supervisory personnel g.- maintaining work-discipline of the supervisory personnel h.- maintaining work-discipline of the remainder employees	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0
9.	Social welfare activity, i.e. a.- canteen /snack-bar/ and regenerative meals b.- kiosk and a shop on the grounds of the mine c.- nursery school d.- nursery e.- vacational school at the mine f.- medical service, sanatoriums g.- social activity within the scope of hollidays for adults and children h.- recreational activity, sports, swimming pools, stadiums i.- cultural and educational activity /houses of culture, miners'clubs etc./	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0

10.	Activity within the scope of work-safety, baths, dressing rooms etc.	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0
11.	Propaganda activity /radio-studio/	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0
12.	Activity within the scope of reporting and social-economical analyses	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0
13.	Economic calculation and financial activity	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0
14.	Protection of the natural environment /terrain recultivation, savage treatment, mine water/	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0
15.	Activity within the scope of mining damages	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0
16.	Fire-fighting protection	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0
17.	Secondary activity /civil engineering, building repairs, gardening/	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0
18.	Investment activity	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0

48.- Taking as the basis 1978 - give the overall OMS in kg/manshift

. . . .

49.- Taking as the basis 1978 - give the underground OMS in kg/manshift

. . . .

50.- Taking as the basis 1978 give the face OMS in kg/manshift

. . . .

51.- Taking as the basis the average prime-cost of 1 ton of coal in 1978 as 100 percent - give the percentage structure of that cost broken down into:

a.- labour . . . . %

b.- materials . . . . %

c.- amortisation . . . . %

d.- power . . . . %

e.- remaining . . . . %

Total 100.00 %

II. [illegible]

1.- What number of employees in 1978 were brought to the work by the mine own means of transport (also including means of transport the mine's disposal, i.e. rented ones).

Total . . . .

including: from a distance of up to 20 km . . . .

from a distance of 21 to 50 km . . . .

from a distance of above 50 km . . . .

2.- What is actually the main direction of manpower recruitation policy for work in the mine:

a.- searching for employees in other regions of the country

b.- recruitation of soldiers released from the military service

c.- vocational school at the mine

d.- local employment department

e.- advertising in daily newspapers

f.- there is no main direction and all possible methods of employees recruitation are being applied

g.- others (indicate which ones) . . . .

. . . .

3.- What is your evaluation of the outside inspections with regard to the efficiency of the mine's functionning: (proper answer to be marked by "x" in the columns below)

influence / inspection	not disturbing the efficiency of functioning	disturbing and disorganizing work	creating difficulties in work
Efficient			
Multiple and not-coordinated			
Too frequent			
Permanent			
Other (Indicate which one)			

How do you evaluate the social-economical infra-structure of the mine:

4.- Number of allocations for service and co-operative lodgings:

a.- entirely covers our demands

b.- only in part covers our demands

c.- are insufficient (less than 25 percent of our demands)

d.- other evaluation . . . .

5.- Number of places in workers' hotels and quorters is:

a.- sufficient

b.- insufficient

6.- Number of places in the mine's nurseries and nursery schools

a.- entirely covers the employees' requirements

b.- only in part covers the employees' requirements

7.- Sport fields, swimming pools, pools, courts etc.

a.- are up to the employees' requirements

b.- are not fulfilling the employees' requirements

8.- Number of places in the vacation centres is

a.- sufficient within the whole year's period

b.- sufficient only within the "post-seasonal" period

c.- sufficient for requirement's but their structure (mountains, lakes, sea) is not adapted to the individual expectations.

d.- other evaluation . . . .

9.- Number of places in the week-end centres:

a.- the mine has no such centres

b.- entirely fulfills the employees' requirements

c.- is in position to receive more guests than the number of those who up to this time have applied for this form of recreation

d.- the number of places is too small for the employees' requirements

e.- other evaluation . . . .

10.- Library, reading room, cinema, concert room etc.

a.- entirely fulfills the employees' requirements

b.- not fulfilling the employees' requirements within that scope

c.- other evaluation . . . .

11.- What is your evaluation of the influence of "disposing centres" from beyond the mine onto the functionning efficiency of the mine (please indicate those which are happening even sporadic);

a.- does not detect any abnormality,

b.- there are too many disposing centres (service, political, technical, supply, etc),

c.- multi-plane subordination distorts the competencies, brings about an excess of regulation tendencies and creates detailed outlines which are normalizing many actions,

d.- overload of existing information-channels brings about that proper information is vanishing or becomes distorted against the intentions of the information transferrer,

e.- a disorganizing influence of any type of decisions, orders, prohibitions of incidental nature is traceable,

f.- lack of coordination in the information text demanded by various disposing centres which causes that the superior authorities (terrain, party, trade union etc) which deal with coincident problematics - take advantage of mutable, frequently excessively detailed information,

g.- cases of lack of correlation between the cyclic and register informations gathered are traceable although the register information should from the base of the cyclic one,

h.- non-precisely assessed competencies of the centres are causing crossing of decisions from various disposing centres in the same subject of activity. This leads to burdensome making agreed and frequently makes it impossible to settle the responsibility for the decision transferred.

12.- By using the point type scale of evaluation from 1 - 7 give a synthetic evaluation of the state of the mine's material supply service in the aspect of the production tasks:

. . . .

13.- Stipulate the preventive measures which are being taken by the mine in case of disturbances in the material supply service:

. . . .

. . . .

. . . .

. . . .

14.- Describe the influence of disturbances of material procurement on the organizational structure of the mine (the point is in calling-up of immediate and/or permanent groups of specialists, sections, and groups of employees).

. . . .

. . . .

. . . .

. . . .

Evaluation of the mine materials management:

15.- Material procurement planning:

a.- number of items of material sortiments used in the mine in 1978 . . . .

b.- what is the denomination and who is in direct charge of material consumption planning section . . . .

. . . .

c.- who and in what time and for which period is elaborating plans of the material consumption . . . .

. . . .

. . . .

16.- Ordering materials and monitoring of deliveries:

a.- are there elaborated plans or delivery schedules of material supply for the mine . . . .

b.- what percentage of ordered materials over a year's period constitute materials covered by reglamentation . . . .

17.- Disposing of materials and accounting their consumption:

a.- does the applied method of material disposing ensure at the same time monitoring of output and material consumption per one ton of output (if so, then in what manner?):

. . . .

. . . .

. . . .

. . . .

b.- what percentage of the total material consumption is being retrieved for repeated use: . . . .

18.- Storing policy:

a.- is there a possibility that the materials be sufficiently secured against their uncontrolled drawing and negative influence of weather conditions:

- YES

- NO

b.- are stores sufficiently equipped with technical means and devices for material storage:

- YES

- NO

19.- Material storage:

a.- considerable quantity of stored materials at differenties in transport are causing that the stores are overcrammed and that it is difficult to keep them clean and orderly,

b.- the store space is not wholly utilized,

c.- the existing store and stock-yard equipment is not suitable and can create danger of accidents,

d.- other evaluation . . . .

. . . .

20.- By using an evaluation scale by points from 1 to 7, give a synthetic evaluation of the state of machinery and equipment repair-management carried out beyond the mine:

. . . .

21.- By using an evaluation scale by points from 1 to 7 give a synthetic evaluation of all the kinds of transportation servicing the mine:

	from the mine	to the mine
Materials, stowing		
People		
Wastes		
Coal		

22.- By using an evaluation scale by points from 1 to 7 give a synthetic evaluation of the railway-transport servicing the mine:

	from the mine	to the mine
Materials, stowing		
People		
Wastes		
Coal		

23.- By using an evaluation scale by points from 1 to 7 give a synthetic evaluation of the state of electric power supply to the mine:

a.- in 1978 . . . .

b.- in 1979 . . . .

24.- By using an evaluation scale by points from 1 to 7 give a synthetic evaluation of the essential cooperation of science with the mine (mutual services)

. . . .

25.- What size of min annual output in 1978 was designed for export (in thousand tons).

. . . .

26.- Localization of the mine. Is there another mine localized within a radius of 20 km?

- NO

- YES: - one mine,
  - two mines,
  - three mines,
  - four mines,
  - five and more mines.

27.- Indicate scientific institutions with whom the mine has agreements on scientific and technical cooperation:

a.- long-term . . . .

. . . .

b.- annual . . . .

. . . .

c.- other (what kind and with whom) . . . .

. . . .

28.- What forms of cooperation (and with what scientific institutions) is realized by the mine?

a.- consultancy and advice with individual scientists who are on special agreements with the mine from:

. . . .

b.- agreements on analyses and fragmentary research with:

. . . .

c.- implementation of new technologies and technical solutions with the aid of:

. . . .

d.- implementation of new organizational solutions, with the aid of:

. . . .

e.- scientific scholarships for the students from:

. . . .

f.- education of the employees for the mine needs in:

. . . .

g.- others (what kind and with whom?): . . . .

. . . .

. . . .

29.- Give number of technical implementations coming from outside:

a.- in 1978 . . . .

b.- from the beginning of 1979 . . . . (including also those which are being implemented).

30.- Give number of organizational implementations coming from the outside:

a.- in 1978 . . . .

b.- from the beginning of 1979 . . . . (including also those which are being implemented)

31.- Do the mine's employees take part in the scientific-research and design works of the institutes and research and development centres:

a.- NO

b.- YES (indicate number of persons and in what form)

. . . .

. . . .

. . . .

32.- Indicate the economic, scientific, social-political and profesional organizations outside the ministry of mining with whom the mine maintains:

a.- permanent working contacts. . . . .

. . . .

. . . .

b.- occasional contacts, sporadic and/or periodical:

. . . .

. . . .

. . . .

. . . .

III. - Structuralization of actions in the mine

Direction of activity	Item	Question no. 1 A C T I V I T Y	Is the given activity carried on in the mine: 1. YES, by the mine 2. YES, but the activity is in part ordered outside the mine. 3. YES, but the ectivity is carried on exclusively by the superior units. 4. YES, but the activity is wholly ordered outside the mine. 5. No activity is being carried on at all.	If YES: "1" or "2" or "3" then has there been appointed a special section to carry on <u>this and only this activity</u>: 1. - YES, 2. - NO, but the given activity is being carried on by a section which also carries on other activities, 3. - NO, but the given activity is carried on by at least one person specially appointed for this purpose. 4. - No, but the activity is being carried on by at least one person who carries also other activities	Denote symbol and denomination of the organizational section
Research and development	1.	Searching for new technologies resulting from actual conditions.	1 2 3 4 5	1 2 3 4	
	[illegible]	Introduction of achievements resulting from the scientific technical progress	1 2 3 4 5	1 2 3 4	
	2.	Searching for new solutions within the scope of machinery and equipment	1 2 3 4 5	1 2 3 4	
	3.	Introduction of new solutions within the scope of automatization	1 2 3 4 5	1 2 3 4	
	4.	Carrying out research work within the scope of computer technology	1 2 3 4 5	1 2 3 4	

Continuation of question 1 from page 1

	5.	Searching for new organizational solutions and improvements	1 2 3 4 5	1 2 3 4	
	6.	Cooperation with scientific research centres	1 2 3 4 5	1 2 3 4	
Preparation of production	7.	Selection of technology, equipment and organization for new faces	1 2 3 4 5	1 2 3 4	
	8.	Establishing mining front	1 2 3 4 5	1 2 3 4	
	9.	Establishing of production capacities	1 2 3 4 5	1 2 3 4	
	10.	Technical standardization of jobs	1 2 3 4 5	1 2 3 4	
	11.	Research on time and methods of work	1 2 3 4 5	1 2 3 4	
Exploitation	12.	Conducting mining work	1 2 3 4 5	1 2 3 4	
	13.	Transportation of gotten underground	1 2 3 4 5	1 2 3 4	
	14.	Transportation of materials underground	1 2 3 4 5	1 2 3 4	
	15.	Coal preparation	1 2 3 4 5	1 2 3 4	
	16.	Coal quality inspection	1 2 3 4 5	1 2 3 4	
	17.	Forwarding and sale	1 2 3 4 5	1 2 3 4	
..tenance	18.	Maintenance of machines and equipment	1 2 3 4 5	1 2 3 4	
	19.	Current repairs and overhauls	1 2 3 4 5	1 2 3 4	
	20.	General overhauls	1 2 3 4 5	1 2 3 4	
	21.	Hire of machines and equipment	1 2 3 4 5	1 2 3 4	

Continuation of question 1
from page 1

	22.	Energetic economy	1 2 3 4 5	1 2 3 4	
	23.	Inter-communication underground	1 2 3 4 5	1 2 3 4	
Supplying and stock policy	24.	Stock spares management	1 2 3 4 5	1 2 3 4	
	25.	Machines and equipment supplying and management			
	26.	Supplying with protective clothing	1 2 3 4 5	1 2 3 4	
	27.	Reserves management	1 2 3 4 5	1 2 3 4	
	28.	Stock-taking activity	1 2 3 4 5	1 2 3 4	
Economic planning	29.	Long-term planning	1 2 3 4 5	1 2 3 4	
	30.	Tactical planning	1 2 3 4 5	1 2 3 4	
	31.	Operative planning	1 2 3 4 5	1 2 3 4	
[illegible]-power management	32.	Recruiting and selection of personnel	1 2 3 4 5	1 2 3 4	
	33.	Training and improving of personnel	1 2 3 4 5	1 2 3 4	
	34.	Training and improving of reserve supervisory personnel	1 2 3 4 5	1 2 3 4	
	35.	Bonuses and rewards for the supervisory personnel	1 2 3 4 5	1 2 3 4	
	36.	Promoting and distinguishing personnel	1 2 3 4 5	1 2 3 4	
	37.	Recruiting and periodical evaluation of the supervisory personnel	1 2 3 4 5	1 2 3 4	
	38.	Maintaining of work discipline of the supervisory personnel	1 2 3 4 5	1 2 3 4	
	39.	Maintaining of work discipline of the personnel	1 2 3 4 5	1 2 3 4	

Continuation of question 1
from page 1

Social-welfare activity	40.	Canteen /snack-bar/ and regenerative meals	1 2 3 4 5	1 2 3 4	
	41.	Kiosk and shop on the ground of mine	1 2 3 4 5	1 2 3 4	
	42.	Nursery school	1 2 3 4 5	1 2 3 4	
	43.	Nursery	1 2 3 4 5	1 2 3 4	
	44.	Vocational school at the mine	1 2 3 4 5	1 2 3 4	
	45.	Medical care-sanatoriums	1 2 3 4 5	1 2 3 4	
	46.	Social welfare action relating to vacations and summer vacations for children	1 2 3 4 5	1 2 3 4	
	47.	Recreational activity, sports, swimming pools, stadiums	1 2 3 4 5	1 2 3 4	
	48.	Cultural and educational activity /houses of culture, miner's clubs, libraries, excursions, etc./	1 2 3 4 5	1 2 3 4	
Other activity	49.	Work-safety activity /baths', cloakrooms/	1 2 3 4 5	1 2 3 4	
	50.	Propaganda activity /radio-studio/	1 2 3 4 5	1 2 3 4	
	51.	Reporting activity	1 2 3 4 5	1 2 3 4	
	52.	Economic and social analyses	1 2 3 4 5	1 2 3 4	
	53.	Economic accounts	1 2 3 4 5	1 2 3 4	
	54.	Financial activity	1 2 3 4 5	1 2 3 4	

Continuation of question 1
from page 1

Other activity	55.	Protection of the environment /terrain re-cultivation, sewage treatmen., mine waters/	1 2 3 4 5	1 2 3 4	
	56.	Activity relating to mining damages	1 2 3 4 5	1 2 3 4	
	57.	Fire-fighting protection	1 2 3 4 5	1 2 3 4	
	58.	Incidental activity, /civil engineering, building repairs, gardening etc./	1 2 3 4 5	1 2 3 4	
	59.	Investment activity	1 2 3 4 5	1 2 3 4	

Direction of activity	Item	Question no. ? Activity	Is the activity carried on: 1. continuously, extemporaneously, everyday 2. regularly, in cyclically repeated periods 3. depending on needs, occasionally, irregularly.	If "2" or "3", then how frequently are carried on those activities: 1. more frequently than once a week 2. once a week 3. every 2 weeks 4. once a month 5. once a quarter 6. every 6 months 7. once a year 8. more rarely than once a year 9. otherwise /e.g. acc. to time schedule/	Is the nearby denoted frequency: 1. strictly fixed by regulation. 2. Fixed in writing only with regard to the lower limit. 3. Fixed in writing only with regard to the upper limit 4. Not determined by any regulation	What kind of regulation is it. 1. in force within the working plant 2. issued by the division 3. issued by the Ministry of Mining 4. state act 5. other
Research and development	1.	Searching for new technologies resulting out of the actual conditions	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	2.	Introduction of achievements resulting out of the scientific technical progress	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	3.	Searching for new solutions within the scope of new machinery and equipment	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	4.	Introduction of new solutions within the scope of automatization	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	5.	Carrying out research work within the scope of computer technology	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5

Continuation of question no. 2
from page 6

	6.	Searching for new solutions within the scope of organization and improvements	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	7.	Cooperation within the scientific-research centres	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
Preparation of production	8.	Selection of technology, equipment and organization for new faces	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	9.	Establishing of the mining front	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	10.	Establishing of the production capacity	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	11.	Technical standardization of jobs	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	12.	Research on time and the methods of work	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
Exploitation	13.	Conducting of mining work	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	14.	Transportation of gotten underground	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	15.	Transportation of materials underground	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	16.	Coal preparation	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	17.	Coal quality inspection	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	18.	Forwarding and sale	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
Maintenance	19.	Maintenance of machines and equipment	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	20.	Current repairs and overhauls	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	21.	General overhauls	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	22.	Hire of machines and equipment	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5

Continuation of question [illegible] from page 6

	No.	Item					
	23.	Energetic economy	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	24.	Inter-communication underground	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	25.	Stock spares management	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
Supplying and stock policy	26.	Machines and equipment supplying and management	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	27.	Supplying with protective clothing	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	28.	Reserves management	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	29.	Stock-taking activity	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
Economy planning	30.	Long term planning	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	31.	Tactical planning	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	32.	Operative planning	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	33.	Recruiting and selection of personnel	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	34.	Training and improving of personnel	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	35.	Training and improving of reserve supervisory personnel	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
[illegible] management	36.	Bonuses and rewards for the supervisory personnel	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	37.	Promoting and distinguishing of personnel	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	[illegible]	[illegible] periodical evalu- [illegible] personnel	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	[illegible]
	[illegible]	[illegible] discipline of [illegible]	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	[illegible]
	[illegible]	[illegible] discipline of [illegible]	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	[illegible]

Continuation of question no. 2
from page 6

Social welfare activity	41.	Canteen /Snack-bar/ and regenerative meals	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	42.	Kiosk and shop on grounds of the mine	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	43.	Nursery school	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	44.	Nursery	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	45.	Vocational school at the mine	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	46.	Medical care and sanatoriums	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	47.	Social-welfare action relating to vacations for children	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	48.	Recreational activity, sports, swimming pools, stadiums	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	49.	Cultural and educational activity /houses of culture, miner's clubs, libraries, excursions etc./	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
Other activities	50.	Work-safety activity, baths, cloak rooms	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	51.	Propaganda activity /radio-studio/	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	52.	Activity within the scope of reporting	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	53.	Carrying of economical and social analyses	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	54.	Economic account	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	55.	Financial activity	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5

Continuation of question no. 2
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Other activities	56.	Protection of the environment /re-cultivation of terrain, sewage treatment, mine waters/	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	57.	Activity relating to mining da-mages	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	58.	Fire-fighting protection	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	59.	Incidental activity /civil engine-ering, building repairs, garden-ing etc./	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5
	60.	Investment activity	1 2 3	1 2 3 4 5 6 7 8 9	1 2 3 4	1 2 3 4 5

Direction of activity	Item	Question no. 3 Activity	Are check-ups and inspections being made of the conducted activity ? 1. "YES" 2. "NO"	If "YES", how frequent are they: 1.daily 2.once a week 3.every two weeks 4.once a month 5.once a quarter 6.every six months 7.once a year 8.more rarely than once a year 9.otherwise, /e.g.acc.to time schedule/	If "YES" are they carried out 1.individually only 2.collectively only 3.individually and collectively	If "1" from the nearby column then who performs the inspection individually? If "2" or "3" - who is a member of the collective body. 1.Managing director of the mine. 2.Chief engineer. 3.Main engineer of the relevant department, 4. Main specialists, independent employees, 5. Heads of departments, 6.Section managers, 7.Representative of the mine's committee, 8.Representative of the workers council, 9. Representative of the works committee of the PUWP, 10. Representative of the Ministry of Mining, 11. Representative of another superior authority, 12.Representative of a social-political authority from the outside, 13. Representative of the internal financial inspection, 14. Representative of the external financial inspection
Research and development	1.	Searching for new technologies resulting out of the actual conditions	1 2	1-2-3-4-5-6-7-8-9	1 2 3	1-2-3-4-5-6-7-8-9-10-11-12-13-14
	2.	Introduction of achievements resulting out of the scientific technical progress	1 2	1-2-3-4-5-6-7-8-9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	3.	Searching for new solutions within the scope of new machinery and equipment	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	4.	[illegible] of new solutions within the scope of automatization	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14

Prepa-ration of production	5.	Carrying out research work within the scope of computer technology	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	6.	Searching for new orga-nizational solutions and improvements	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	7.	Cooperation with the scien-tific technical centres	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	8.	Selection of technologies, equipment and organization for new faces	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	9.	Establishing mining front	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	10.	Establishing of production capacity	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	11.	Technical standardization of jobs	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	12.	Research on time of work and methods	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
Exploi-tation	13.	Conducting of mining work	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	14.	Transportation of gotten underground	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	15.	Transportation of materials underground	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14

Maintenance	16.	Coal preparation	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	17.	Coal quality inspection	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	18.	Forwarding and sale	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 5 7 8 9 10 11 12 13 14
	19.	Maintenance of machines and equipment	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5·6 7 8 9 10 11 12 13 14
	20.	Current repairs and overhauls	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	21.	General repairs	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	22.	Hire of machines and equipment	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	23.	Energetic management	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	24.	Inter-communication underground	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
Supplying and stock	25.	Stock spares management	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	26.	Machines and equipment supplying	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	27.	Supplying with protective clothing	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	28.	Reserves management	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	29.	Stock-taking activity	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14

	30.	Long-term planning	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	31.	Tactical planning	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	32.	Operative planning	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
Personnel management	33.	Recruiting and selection of personnel	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	34.	Training and improving of personnel	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	35.	Training and improving of reserve personnel	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	36.	Bonuses and rewards for the supervisory personnel	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	37.	Promoting and distinguishing of personnel	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	38.	Recruiting and periodical evaluation of the supersisory personnel	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	39.	Maintaining of work of discipline the supervisory person	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	40.	Maintaining of work of discipline of the personnel	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
Social welfare activity	41.	Canteen /snack-bar/ and regenerative meals	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	42.	Kiosk,and shop on grounds of the mine	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	43.	Nursery school	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	44.	Nursery	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	45.	Vacational school at thé mine	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14

Social welfare activity	46.	Medical care, sanatoriums	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	47.	Social-welfare activity relating to vacations and summer vacations for children	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	48.	Rècreational activity /sports swimming pools, stadiums/	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	49.	Cultural and educational activity /houses of culture, miner's clubs, libraries, excursions etc./	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
Other activities	50.	Work safety activity, baths, cloak-rooms	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	51.	Propaganda activity /radio-studio/	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	52.	Activity within the scope of reporting	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	53.	Carrying of economic and social analyses	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	54.	Economic account	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	55.	Financial activity	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	56.	Protection of environment /terrain re-cultivation, sewage treatment, mine waters etc./	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
	57.	Activity relating to mining damages	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14

58.	Fire-fighting protection	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
59.	Incidental activity /civil engineering, building repairs, gardening/	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14
60.	Investment activity	1 2	1 2 3 4 5 6 7 8 9	1 2 3	1 2 3 4 5 6 7 8 9 10 11 12 13 14

Direction of activity	Item	Question no. 4 ACTIVITY	Are there organized conferences, sessions consultations regarding carrying on of activities: 1."YES" 2."NO"	If "YES", then how frequently: 1.-more frequently than once a week 2.-once a week 3.-every two weeks 4.-once a month 5.-once a quarter of a year 6.-every six months 7.-once a year 8.-more rarely than once a year 9.-otherwise	If "YES"then who most frequently is taking part in those conferencies,sessions consultations: 1.Representative of the Ministry of Mining. 2.Representative of the given union of coal industry. 3.Representative of the social-political organization outside the mine. 4. Representative of terrain authorities. 5. Managing director of the mine. 6. Chief engineer of the mine. 7.Main engineer of the corresponding department. 8. Main specialists,self-dependent employees. 9. Heads of departments. 10. Section managers. 11. Personnel of departments and sections. 12. Section managers. 13.Representative of the workers council. 14.Representative of the mine's council. 15.Representative of the works committee of the PUWP. 16.Representatives of other social-political organizations. 17.Representatives of institutes,research and development centres.18.Others,not mentioned above.
Research and development	1.	Searching for new technologies resulting out of the actual conditions	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	2.	Introduction of achievements resulting out of scientific-techn.progress	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	3.	Searching for new solutions within the scope of new machines and equipment	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	4.	Introduction of new solutions within the scope of automatization	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	5.	Carrying-out research-work within the scope of computer technology	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	6.	Searching for new organizational solutions and improvements.	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

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Preparation of production	7.	Cooperation with the scientific-technical centres	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	8.	Selection of technologies equipment and organization for new faces	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	9.	Establishing of mining front	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	10.	Establishing of production capacities	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	11.	Technical standardization of jobs	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	12.	Research on time and the methods of work	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Exploitation	13.	Conducting of mining work	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	14.	Transportation of gotten underground	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	15.	Transportation of materials underground	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	16.	Coal preparation	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	17.	Coal quality inspection	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	18.	Forwarding and sale	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Maintenance	19.	Maintenance of machines and equipment	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	20.	Current repairs and overhauls	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	21.	General overhauls	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	22.	Hire of machines and equipment	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	23.	Energetic economy	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	24.	Inter-communication underground	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Supplying and stock policy	25.	Stock spares management	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	26.	Machines and equipment supplying and management	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	27.	Supplying with protective clothing	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	28.	Reserves management	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	29.	Stock-taking activity	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	30.	Long-term planning	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Economic planning	31.	Tactical planning	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 19
	32.	Operative planning	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Personnel management	33.	Recruiting and selection of personnel	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	34.	Training and improving of personnel	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	35.	Training and improving of reserve supervisory personnel	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	36.	Bonuses and rewards for the supervisory personnel	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	37.	Promoting and distinguishing of employees	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	38.	Recruiting and periodical evaluation of the supervisory personnel	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	39.	Maintaining of work discipline of the supervisory personnel	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Social welfare activity	40.	Maintaining of work discipline of the personnel	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	41.	Canteen /snack-bar/ and regenerative meals	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	42.	Kiosk and shop on the ground of mine	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	43.	Nursery school	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	44.	Nursery	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Social welfare activity cont.	45.	Vacational school at the mine	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	46.	Medical care,sanatoriums	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	47.	Social welfare action relating to vacations and summer vacations for children	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	48.	Recreating activity,sport, swimming pools,stadiums	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	49.	Cultural-educational activity /houses of culture, miner's clubs,libraries, excursions, etc./	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Other activities	50.	Work-safety activity,baths, cloak rooms	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	51.	Propaganda activity /radio-studio/	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	52.	Activity within the scope of reporting	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	53.	Economic and social analyses	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13c14 15 16 17 18
	54.	Economic account	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	55.	Financial activity	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Other activities /contd./	56.	Protection of the environment /terrain recultivation, sewage treatment, mine waters/	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	57.	Activity relating to mining damages	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	58.	Fire-fighting protection	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	59.	Incidental activity /civil engineering, building repairs, gardening/	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
	60.	Investment activity	1 2	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Directions of activity	Item	Question no. 5 A U T H O R I Z E D A C T I V I T Y	Who is the last person who can give consent to that authorized activity be assumed: 1. Managing director of the mine. 2. Director of the functional department. 3. Chief engineer. 4. Main engineer of the correponding department. 5. Main specialists, self-dependent specialists. 6. Head of department. 7. Section menager. 8. Excenting employee. 9. Secretary of the works committee of the PUWP. 10. President of the mine's committee 11. President of the workers' council. 12. Secretary of the workers' autonomy committee. 13. Presidium of the mine's council. 14. Mine's council.15.Executive . 16. The mine's superior authorities. 17. Cthers /persons, authorities, resorts etc./.
Research and development	1.	Searching for new technologies resulting out of the actual conditions	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
	2.	Introduction of achievements resulting out of the scientific technical progress	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
	3.	Searching for new solutions within the scope of new machinery and equipment	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
	4.	Introduction of new solutions within the scope of automatization	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
	5.	Carrying out research work within the scope of computer technology	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
	6.	Searching for new organizational solutions and improvements	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

Preparation of production	7.	Cooperation with scientific-technical centres	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	8.	Selection of technologies, equipment and organization for new faces	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	9.	Establishing of the mining front	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	10.	Establishing of the production capacities	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	11.	Technical standardization of jobs	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	12.	Research on time and the methods of work	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	13.	Conducting of mining work	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Exploitation	14.	Transportation of gotten underground	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	15.	Transportation of materials underground	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	16.	Coal preparation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	17.	Coal quality inspection	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	18.	Forwarding and sale	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Maintenance	19.	Maintenance of machines and equipment	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	20.	Current repairs and overhauls	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	21.	General overhauls	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	22.	Hire of machines and equipment	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	23.	Energetic economy	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	24.	Inter-communication underground	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Supplying and stock policy	25.	Stock spares management	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	26.	Machines and equipment supplying and management	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	27.	Supplying with protective clothing	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	28.	Reserves management	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	29.	Stock taking activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Economic planning	30.	Long-term planning	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	31.	Tactical planning	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	32.	Operative planning	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Personnel management	33.	Recruiting and selection of personnel	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	34.	Training and improving of personnel	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	35.	Training and improving of reserve supervisory personnel	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	36.	Bonuses and rewards for the supervisory personnel	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	37.	Promoting and distinguishing employees	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	38.	Recruiting and periodical evaluation of supervisory personnel	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	39.	Maintaining of work discipline of the supervisory personnel	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	40.	Maintaining of work discipline of the personnel	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
[illegible] wel- [illegible] acti- [illegible]	41.	Canteen /snack-bar/ and regenerative meals	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	42.	Kiosk, shop on the ground of mine	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Social welfare activity	43.	Nursery school	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	44.	Nursery	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	45.	Vacational school at the mine	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	46.	Medical care, sanatoriums	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	47.	Social welfare activity relating to vacation and summer vacation for children	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	48.	Recreation activity, sport, swimming pools, stadiums	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	49.	Cultural-educational activity /houses of culture, miner's clubs, libraries, excursions, etc./	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Other activities	50.	Work-safety activity, baths, cloak-rooms	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	51.	Propaganda activity /radio-studio/	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	52.	Activity within the scope of reporting	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	53.	Carrying out economic and social analyses	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	54.	Economic account	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	55.	Financial activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	56.	Protection of environment /recultivation of terrain, sewage treatment, mine waters etc./	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	57.	Activity relating to mining damages	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	58.	Fire-fighting protection	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Other activities	59.	Incidental activity /civil engineering, building repairs, gardening etc./	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	60.	Investment activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

MANAGEMENT INFORMATION SYSTEM IN THE MINING INDUSTRY

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This topic has been in comparison with the initial design intrinsicly reduced. The reason has been the very short period for preparation, which unabled us to create from quite vast material available homogeneous representing real range and approach to the solving of information systems. And so we have limited ourselves only to those parts, whose presentation is easy within limited time and which can create the image about range of the solution.

The solving of information systems is the integrated part of the solving of the management systems generally. From the special system point of view the management system is divided into s u b - s y s t e m o f d e c i s i o n - m a k i n g, it means all non-algorithmized transformations of information, and into the s u b s y s t e m o f i n f o r m a t i o n , which is represented by collecting, transmition and storing and by all algorithmized transformations. By the way, this decomposition makes possible perfect appreciation of the human role in the management systems and the determination of the level of automation. The decision-making is in this conception an attribute of man. Machines cannot make decisions.

It is not necessary to continue this meditation now. We'll return in several notes to the information systems. We would like to stress that we consider the information to be a property of society. If we look into the past, we can see, that in the times of low productivity the needs of society were material. The basic demands for

for people were food, housing, clothing. Even today these needs are basic in the life of inhabitants of developing countries. However the need of energy is playing higher importance in developed countries. Hardly anybody realises that there is further shift and satisfying of the needs of information is becoming the prime concern.

Shift

MATERIALS ——→ ENERGY ——→ INFORMATION

is and will be connected with changes in the needs as well as the character of management. The inter-relation of these classes will show the degree of development achieved. In other words, there was a limited level of technological equipment in production in the past, today there is a limit to energy and basic raw materials. The shift continues, however, and there will be a problem in the future to fully make the best use of and process the mass of information available. Even today it is possible to watch this position of information. The information system is becoming a secondary production process. This means, that more and more innovations in production will be reached only on the bases of innovation in the information system.

The above facts, however, do not mean that the information system has priority in solving the problems of management. The decomposition of management is decision-making and information. Decision-making has priority, the information system must serve managers. The statement seems as clear and normal, but most deformations in practice come from the fact that they aren't followed.

To be concise, let us leave these types of meditations, which are interesting for us, as they unite a series of seemingly unconnected phenomena. Before we approach the principles of solving information systems, we feel it is necessary to say something about its extent. The quantification of information system was determined according to the method DIS (Documentary of the information system). At that time we were concerned with the most detailed quantification in the enterprise and a research of the extent of the information system OSTRAVA KARVINA REGION - OKR (the largest black coal basin in the CSSR) was made, which is until now the only quantification used by the concern OKR known to us. The information further given is considered as a general illustration of an immense range of information systems. For us to be able to consider these facts, I give as an example that the most daring estimation as to the number of pieces of information at a mine were about 100.000 items during the year. In fact, in the first enterprise there were 40 million. It has proved again that when solving management problems even the most progressive research workers tend to consider the situation as less complicated than it really is. We still cannot content ourselves with the reality, that every t y p e o f m a n a g e m e n t s y s t e m w i t h i t s w i d e r a n g e o u t - d o e s t h e c u r r e n t r a n g e o f o u r t h i n k i n g . To idealise the real situation is another mistake in solving the problem.

And now to the figures, which concern only the written information system. The range of written forms at mines is in the range from 2,969 - 3,589 various types of written forms. The forms from outside are in the range from 857 - 1,078, that means 27,3 % to 35,7 %. The number of forms used in the mine is from 1,907 - 2,511, that is 64,2 % to 72,7 %. About 500 forms are filled out for one function by a clerk and remain with that function, that means approximately 16 % of the forms don´t move. But even in this case they are statistic materials (e.q. books, cards, etc.) which are used mostly by their creators.

The facts about the time required to work out the form from various points of view and the numbers of elementary pieces of information is interesting. The following are figures in average:

- the number of forms worked out in one mine per year is 43,720,000
- the work required per year to work out the forms in one mine 652,000 hours.

The working out of forms requires about 60 % of the working time of office clerks per year.

A research at mines in the OKR show that up to 80 million pieces of information is worked out per year costing 20-25 million crowns at one mine only. In spite of this vast range of information, it is still insufficient to cover all the requirements of management. At a mine 3,500 various types of forms are used whereas at a higher level of management the requirement is 10,000 various types. These forms are worked out for various time scales and with various repetitions. This means that this higher level of management (including the lower level) has for its use about 2 miliard pieces of information all together (we mean only written information, fig. 1). This amount requires 10 million hours of work. When we consider this extent of information system, it is necessary to have in mind, that the only aim of the information system is its being fully made use of by on all levels of management. According to estimations their using in management is about 8 %.

In this case only putting automation into the information system means a fixed present day situation.

It is of no value to give more figures which are at our disposal. We only would like to show the decomposition of information according to the frequency within the time on the figure 2.

We should like to mention some of the problems, which effect the solving of information systems. The first most serious one is the slipping of information systems from the higher level of management to the lower ones. When solving information systems, we often make mistakes by considering the limits of the information systems as identical with the limits of the organisation of the institution or with the limits of the levels of management. In fact they are not identical (fig. 3). Under these circumstances an analysis is necessary. We can speak about the creation of a model information system. On the basis of this model we can determine that on one level of management the information is used by higher levels os management and as such these are not subject to the lower level of management. The solving of the enterprise information system concerns a much smaller part than is generally supposed. This advantage is only seeming, because by partial solving we can`t achieve those results such as complex solutions of information systems.

The result is that the solving must be led from the top to the bottom. It means from the higher levels of management to the lower ones. This conslusion is the result os research of the process of integration,

The mentioned slipping of the information system of the higher level into the lower one is really extensive. For instance on the basis of the model made by the method DIS we learned, the mine`s own information system is only 20 % of all information in the mine. When a solution is found for an information system at the mine, only the above mentioned 20 % may be solved and the remaining 80 % must be solved as an information system of a higher management level (fig. 4).

The way of solving in the direction from bottom to the top cannot be realized. The enterprise when speaking about solving its information system, has the right to solve only those 20 %, but the greatest problem is to determine which 20 % is concerned. The generation chain is so great that without making an adequate model, the solving of the problem is impossible.

Because of limited time we present only briefly the basic principles of solving informatin systems, taking into consideration as a matter of course the use of modern architectures of information banks.

1. The information system is very extensive and painstaking. The basic aim of its solution is to attain its professional management in functioning and development.
2. The corner stone of the information system is an elementary information. There is a big quantity of this information. A half step must be made in the solving process. An expression is being made - information set.
3. The information system is unknown. Therefore it must be recognized and documented.
4. The information systems mean a service for its users. We work with the expression - active user. This expression in our system solving gives the right to put demands on the information systems and make use of the information system and the duty to supply information into the information system. By the choice of active users the solvers determine the range of solving of the information system. An active user may be for instance the deciding process, the organisation department, singular activity managers, etc.
5. The solving of the information system demands its centralisation department which works out the solution and makes the whole information system function. It is called IC - Information Centre.

6. The solving of an information system must be done in a complex manner for the whole level of management. It`s not possible to make only part solutions.

7. The only decomposition of information systems into sub-systems, it means information sets only the first step is made. I t i s n e c e s s a r y t o m a k e g e n e r a t i o n c h a i n i n f o r m a t i o n s e t s (by the help of the method DIS) the so called goal chains are gained. These are the true subsystems of information systems.

8. The chain information sets are another subjects for solving. What is important for us is the fact a l l c o r r e c t i o n s m a d e i n o n e g o a l c h a i n s w i l l n o t o v e r - s t e p i t s l i m i t . For example the solving of the whole IS of the enterprise will fall apart about into 3,500 sub-systems that can be gradually solved. The goal chains are absolutely closed against any changes within.

COMPOSITION OF INFORMATION IN THE MINE

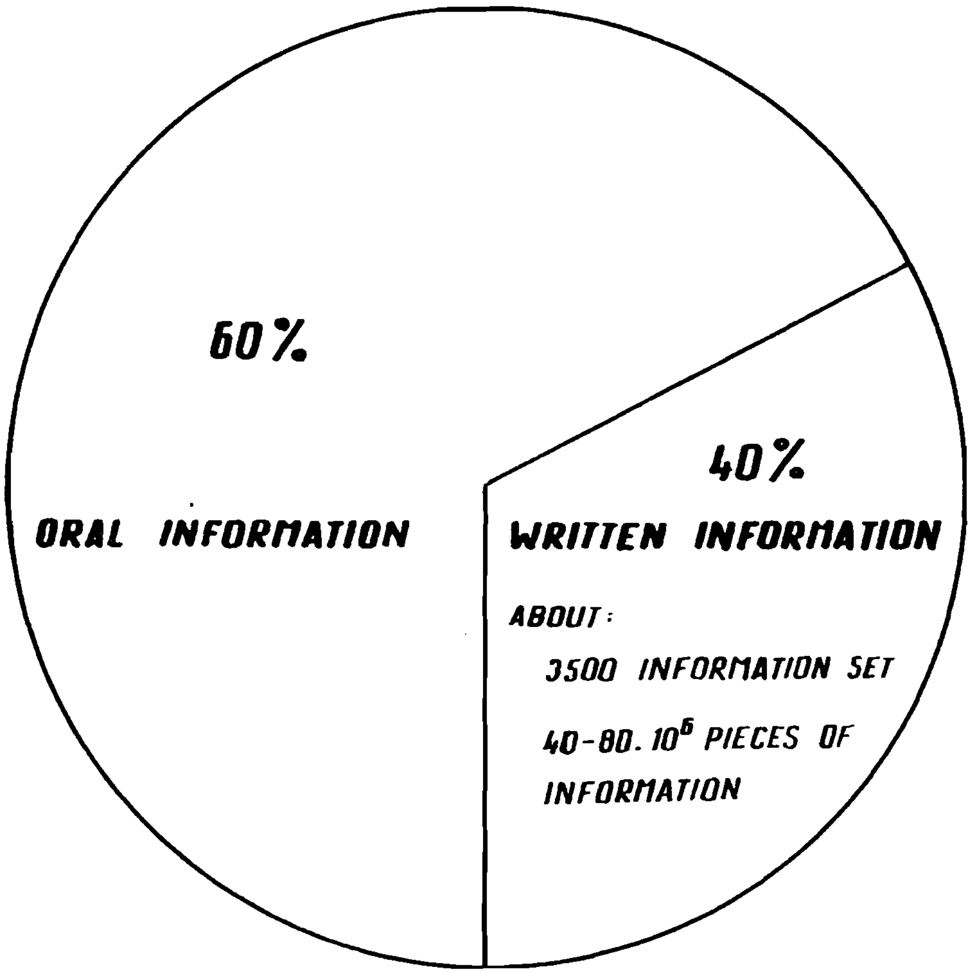

FIGURE 1

DECOMPOSITION OF INFORMATION SYSTEM ACCORDING TO FREQENCY WITHIN TIME

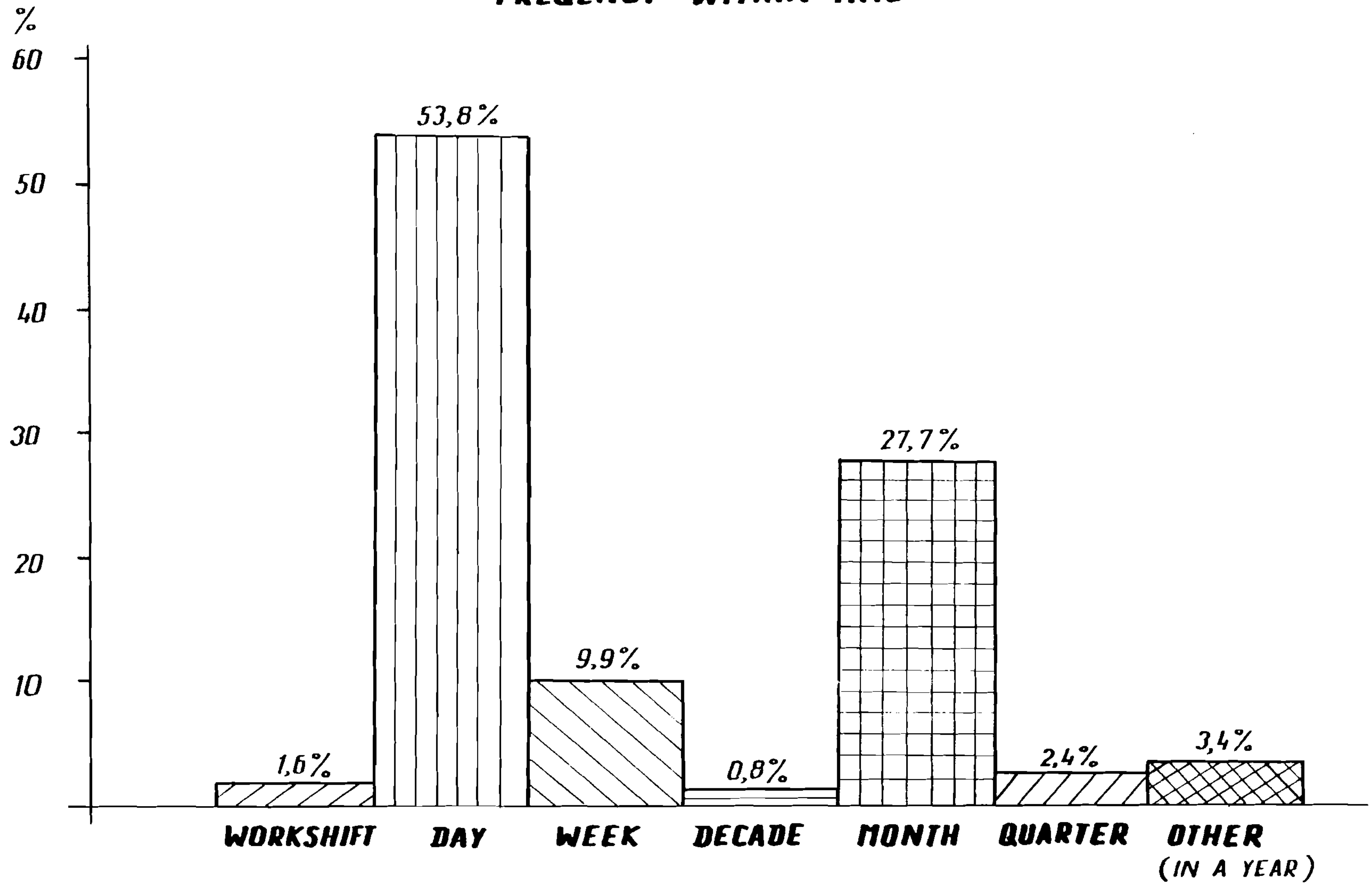

FIGURE 2

DEFINITION OF INFORMATION SYSTEM ON LEVELS OF MANAGEMENT

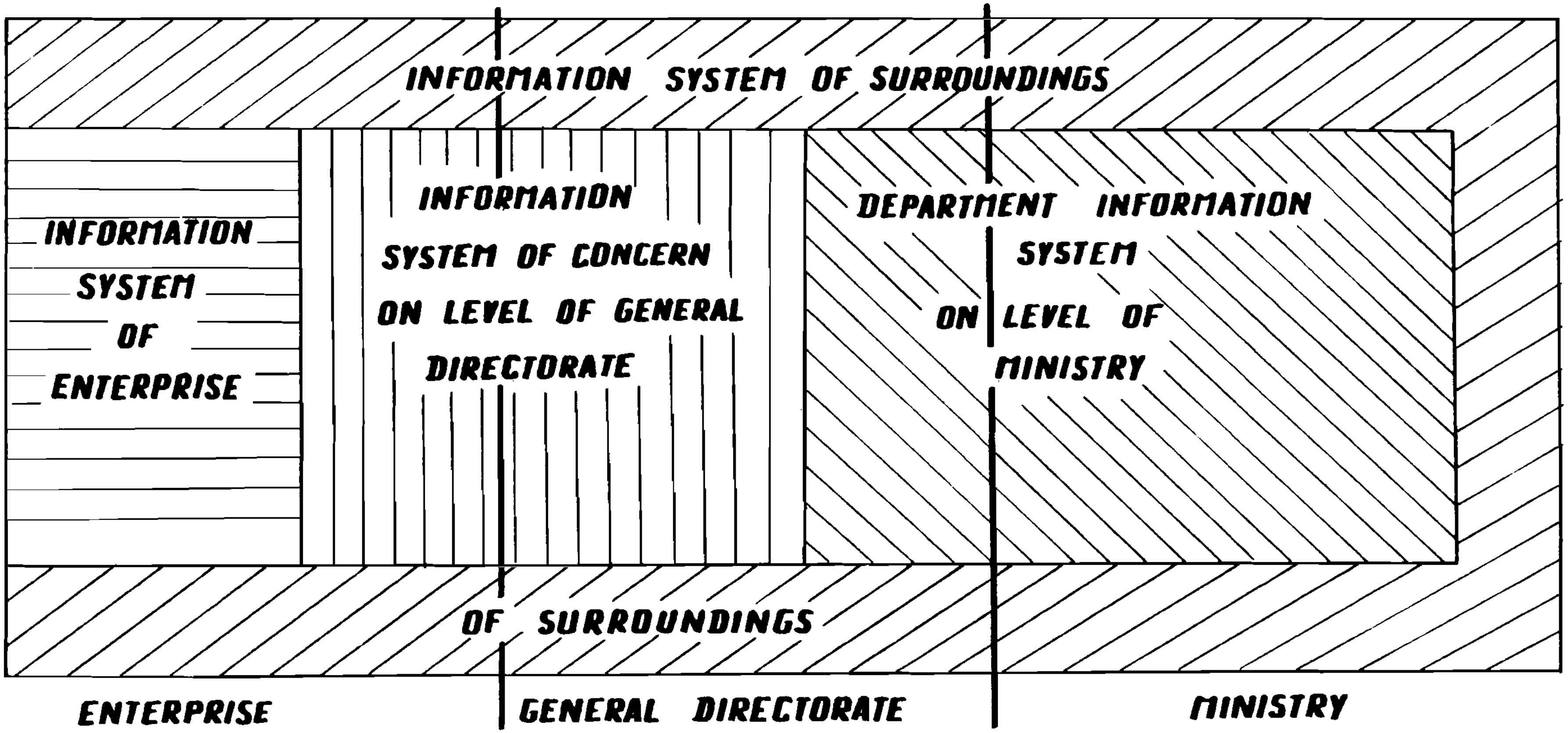

FIGURE 3

HIERARCHY OF INFORMATION SYSTEM OF ONE LEVEL OF MANAGEMENT

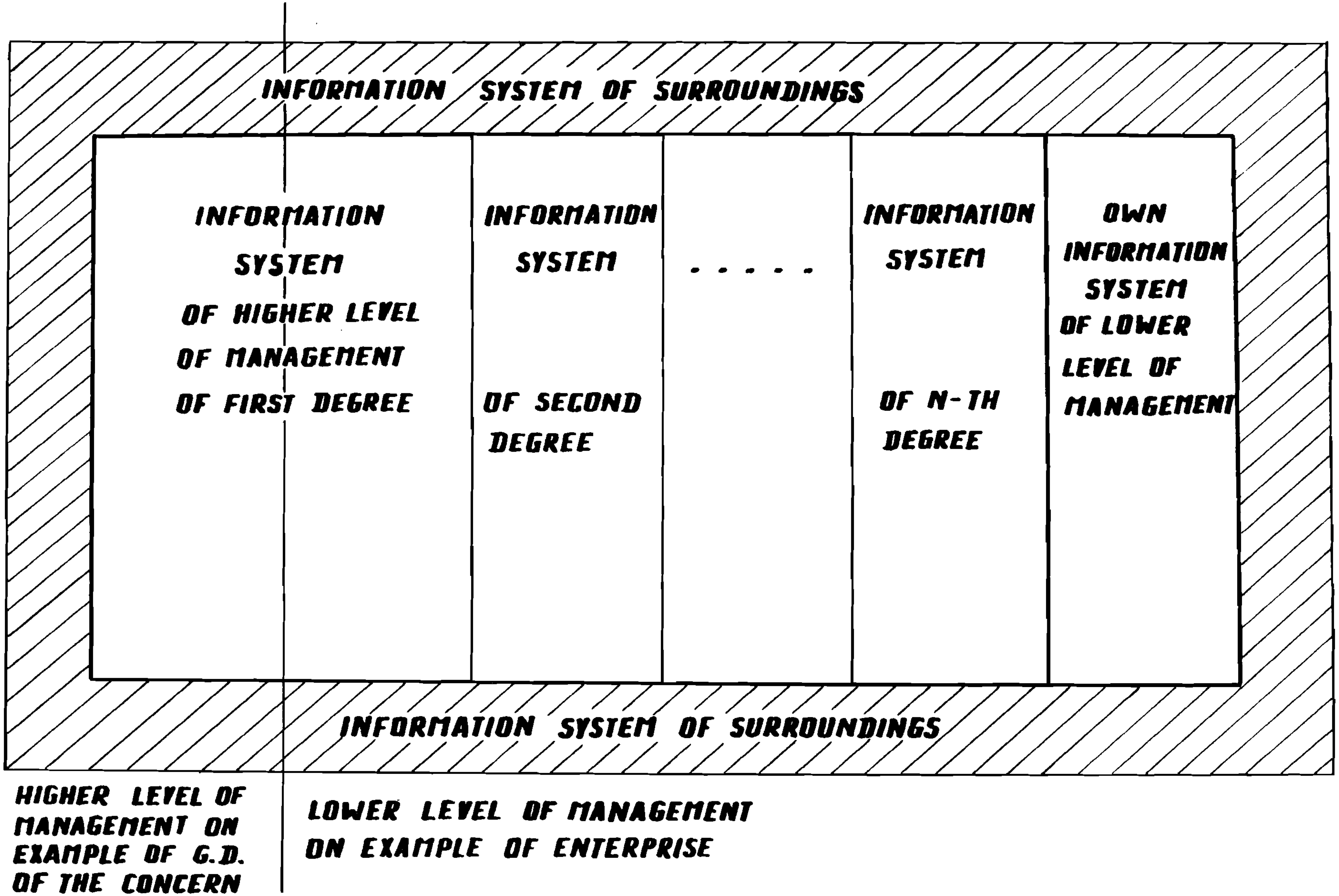

FIGURE 4

A COMPUTER BASED PRODUCTION INFORMATION SYSTEM

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INTRODUCTION

The past few years have seen the introduction of mini-computers on an increasing scale at collieries in the British coal industry. These are being used for controlling underground transport systems, coal preparation plants and fixed plant (pumps etc.); and for monitoring the mine environment and face operations. A separate mini-computer (termed a primary computer) is dedicated to each of these functions. The overall system under which these computers operate is a common one which is applicable at all collieries. The information collected by the primary computers, other than that required for immediate control, will be fed to a secondary computer for analysis and processing. This overall concept, called MINOS (MINe Operating System) is being developed by the National Coal Board's Mining Research and Development Establishment (M.R.D.E.). Eventually most of the data required by the system will be captured automatically. For example, the fact that a delay has occurred on a face, together with the duration of that delay, will be detected automatically via transducers link linked to a primary computer. However, the reason for that delay will, in all likelihood, have to be recorded manually. Such a system is currently under development with the first trial installations now being made.

It will, however be some time before these systems are fully developed and in the intervening period it was thought that useful experience would be gained by using a secondary computer as the basis for an information system with the prime data being fed in manually. Accordingly a team composed of staff from the Board's Computer Services (Compower Ltd) and Operational Research Executive, under the direction of Doncaster Area Computer Liaison Officer, was set up to develop and install such a computer-based management information system at a colliery.

The team had the following terms of reference:

(i) To study the information currently used by management at the colliery.

(ii) To identify improvements in quality, quantity and presentation of information which would aid management.

(iii) To identify the most effective and economic means of providing the information having regard for all the latest computer and automatic data collection equipment.

(iv) To recommend how these techniques could be implemented to improve control of colliery operations.

THE COLLIERY

The colliery chosen for the exercise was Bentley Colliery in the Yorkshire coalfield. This is one of Doncaster Area's ten working collieries and it is situated about four miles north of Doncaster town centre.

Traditionally, the colliery has worked both the Barnsley and Dunsil seams, and since 1972 all production has been from the Dunsil seam which lies about 1,900 ft below ground at Bentley. Currently, Bentley Colliery works three fully mechanised faces, one using a double-ended ranging drum shearer and the others single-ended. Two faces operate advance mining and one retreat mining. Underground transport is by conveyor. Output is fairly steady at around three-quarters of a million tonnes per annum, with over half of this coal destined for power station consumption. New rapid loading bunkers enable a fast turn round for unit trains. About 15% of the output is for the domestic market, the rest goes to local industry, smokeless fuel plants and miners fuel.

THE INFORMATION SURVEY

As a first step a survey was undertaken to identify the existing information flows. All colliery departments and levels of management were consulted and samples of forms in use collected. From these a number of application areas were identified and these are shown schematically in Figure 1.

The forms were then analysed to identify the prime data which was being recorded. Prime data is that information which is based directly on physical occurrences and is not derived from other data. For example, face advance, face length and working height are all items of prime data. Face production however, is not, being estimated from these parameters.

The data was classified into 17 major fields of application, 9 of which relate to production. It was noticeable that some items of information were of interest to one department only but, in general, production detail was used by most departments. Since the data collected on production was so widely used and processed it was concluded that this field of information should be the initial one for computer application. The computer chosen was capable of accepting data input manually and of interfacing with the computers already installed at the colliery for controlling underground transport and for monitoring the environment.

Work toward developing the basic computer programs (software) was undertaken initially at M.R.D.E. Compower and O.R.E. then extended and further developed this, writing additional programs and increasing the scope of the software. Much of this work was undertaken on-site at Bentley. Close liaison was maintained throughout with M.R.D.E., who are still working in similar fields, in order to ensure the system was compatible with possible future automatic data capture.

The computer and related terminals were installed at the colliery in April 1978 and a two-week trial of the system followed, with full 24-hour supervision provided by O.R.E. and Compower.

Amendments were introduced as a result of experience gained during this trial, and the first stages of the system became fully operational at the beginning of May 1978.

THE EQUIPMENT

The production information system at Bentley Colliery is based on the PDP 11/34 mini-computer manufactured by Digital Equipment Corporation. This computer, together with the other equipment mentioned in this paper, is shown diagrammatically in Figure 2.

Data is input to the computer via a Tektronix 4006-1 graphical display terminal located in the Control Room.

Another Tektronix is located in the Deputies' (Foremens') Office for use mainly by the Undermanagers and by ongoing face Officials. It is also planned to install a Tektronix in the main Management Office Block.

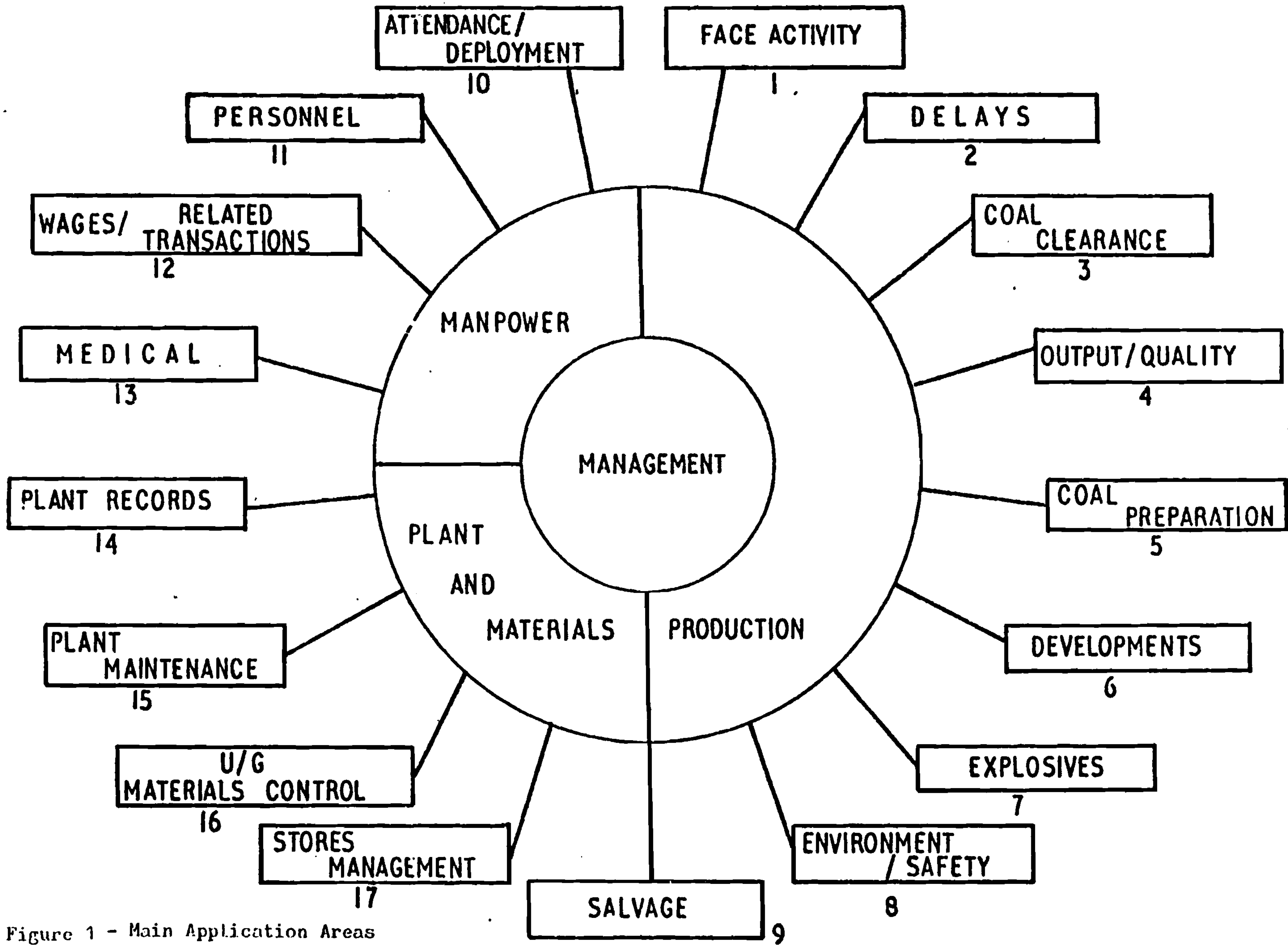


Figure 1 - Main Application Areas

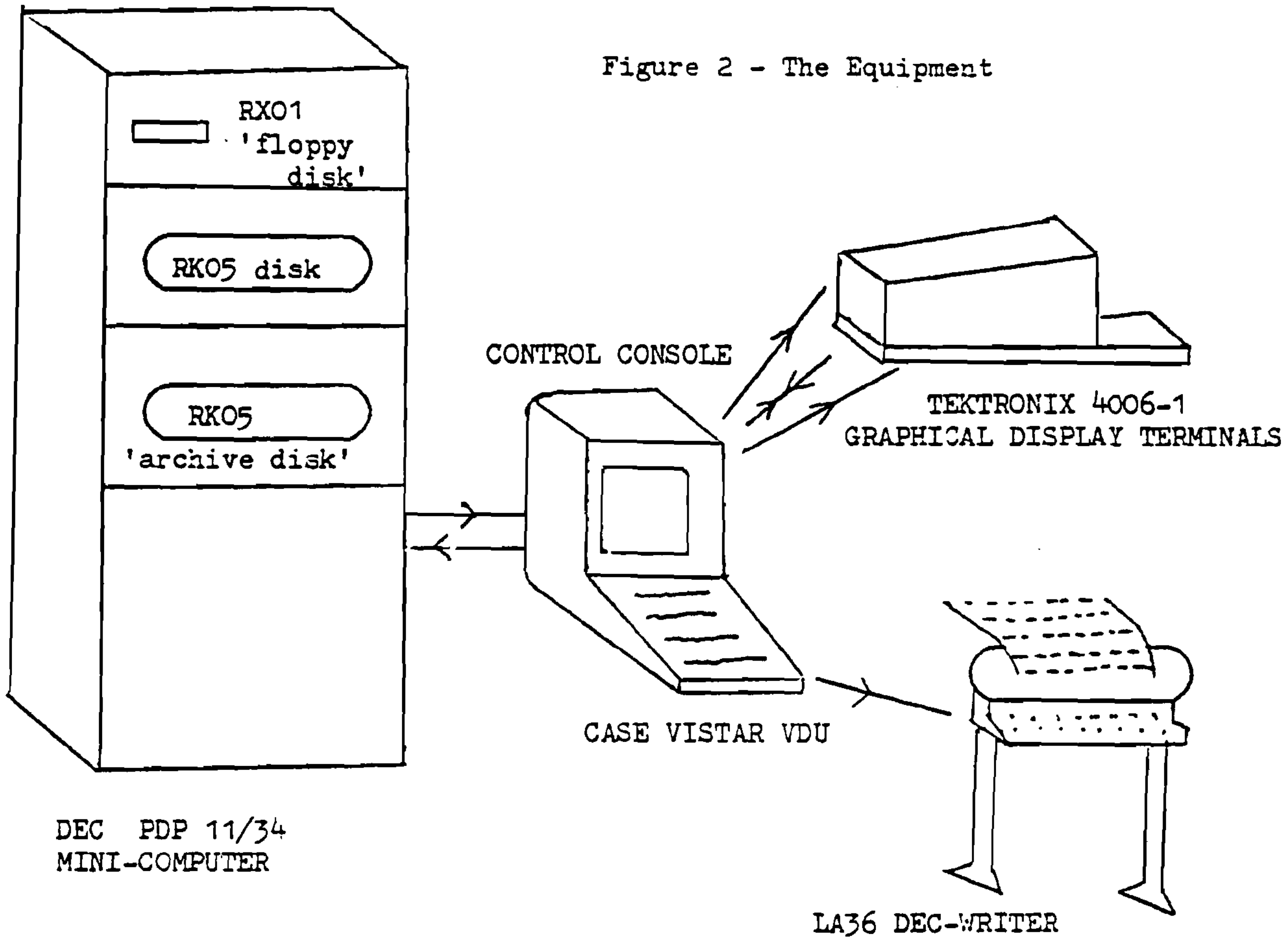


Figure 2 - The Equipment

Reports may be produced on any of the Tektronix screens, or, if a more permanent copy is required on a printer (an LA36 Dec-writer).

The main control console of the system is a Case Vistar visual display unit. This is used by the Operator for selecting (calling) programs and determining against which of the three Tektronix they will run. The system allows for all three Tektronix to be used simultaneously by different users, using different programs.

Data input to the computer is stored on an RK05 disk. At midnight the computer automatically archives the day's data to another RK05 disk, thus producing a duplicate copy of all information held by the system. This reduces the chances of information loss due to the failure of a disk. A disk will hold the order of 6 months' data before being full and requiring replacement.

A link between the PDP 11/34 (secondary) computer and the primary computers (coal clearance, environmental and production monitoring) is currently being developed. This will allow for the long-term storage/analysis of primary data.

A CLIENT ORIENTED SYSTEM

A basic principle laid down early on was that the system must be designed to satisfy the requirements of the client - that is the management concerned. Individual managers have different styles and indeed all collieries are different to a greater or lesser degree. While there is obviously a central core of information which is immediately useful to management at all collieries, the system must be capable of easy modification to produce the information and forms of presentation that any individual manager conceives as being the most useful to him. Unless this is so, the new system will not be used and the manager will either revert to his old system or, if that is not possible, a feeling of irritation will be created. The overall result being a deterioration in the standard of the information system as opposed to the planned improvement.

At the same time the system, once developed, must be easily transferable to other collieries. Otherwise a considerable amount of effort will be wasted in creating a completely new system each time.

INFORMATION FLOW TO THE COMPUTER

The information flow into the information system at Bentley is as follows:

During a Shift

During a shift, detail of machine position along the face is collected regularly by the Controller. Whenever there is a stoppage on a face, the reason for the stoppage and the current machine position are reported by face officials to the Control Room. (The stop and re-start times of the face are noted.) In general most delays longer than about five minutes are reported in this way.

The Controller inputs this delay and machine position information into the Computer via the Tektronix by answering a set of simple questions. The data he inputs is displayed back to him in the form of a graph of machine position against time for verification. His familiarity with the 'usual' gradient of lines on this graph usually enables him to spot any unreported delays of significant duration, or other inconsistencies in the information he has received.

A two-part code is used for inputting reasons for face stoppages. These codes are fairly comprehensive and are compatible with delay codes used nationally within the National Coal Board. Experience has shown that Controllers have little difficulty in using the codes, and we have found they convey information with an acceptable level of detail for management needs.

Should erroneous data be input (as may happen, for example, when a delay is reported initially as being due to X but is subsequently found to be due to Y) the Controller can correct the information held by the computer. All data input since the start of the night shift of the previous day is accessible for editing in this way.

At the end of the Shift

At the end of the shift the Controller inputs manpower figures, details of the face end situation, and the number of skips wound. The number of roadway supports set, and the manning on each development is similarly processed.

Budgets/Standards

A file of budgets/standards/face statistics is held on the computer. This is updated as and when necessary.

The introduction of new faces to the system, or the removal of exhausted faces, involves the use of only one program, and is carried out by colliery personnel.

INFORMATION FLOW FROM THE COMPUTER

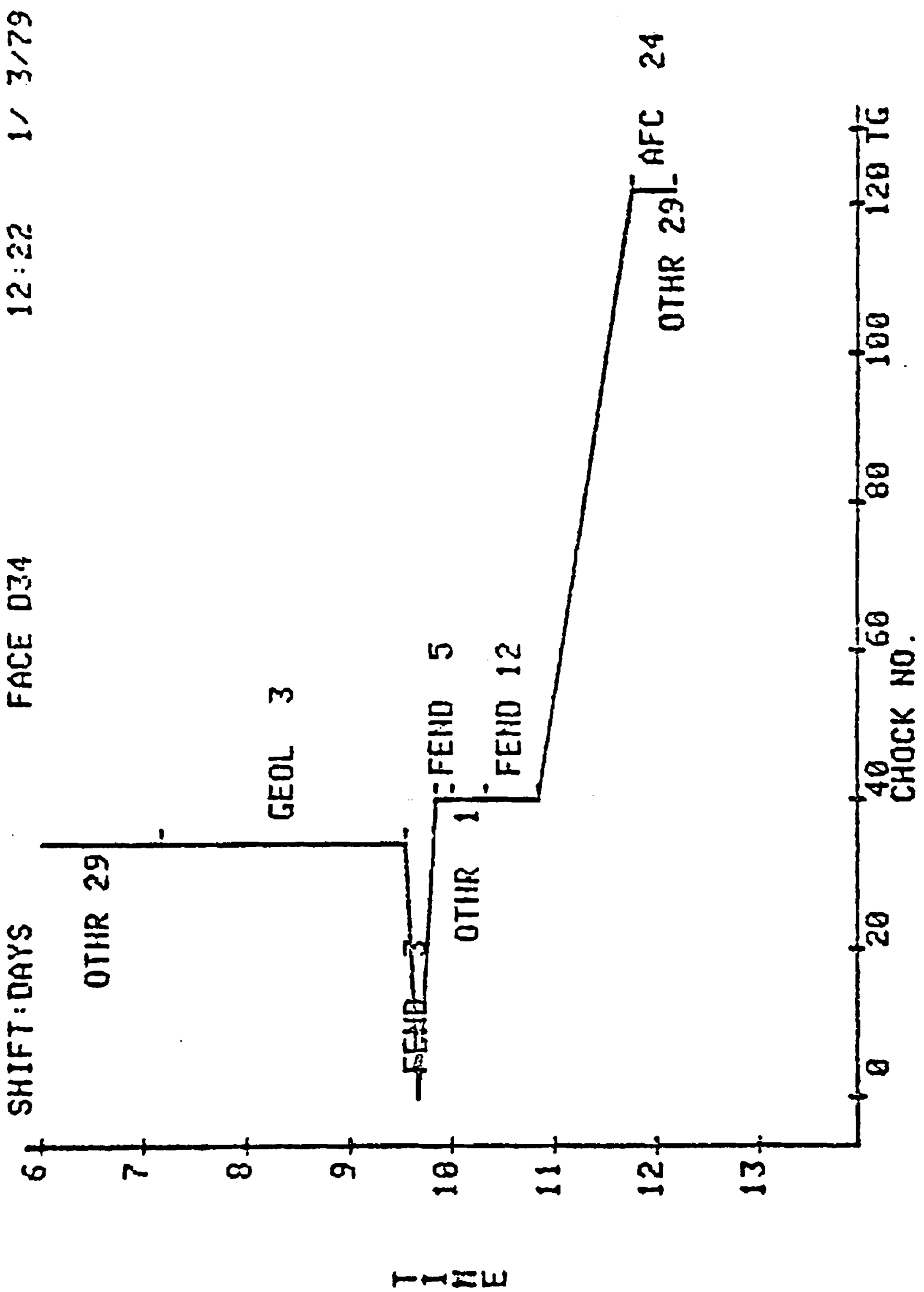
Reports produced by the system are available on request to all members of the Colliery's management team. Certain reports are also produced and issued regularly on a shift, daily, weekly and monthly basis. It is not possible in a paper of this length to outline all of these but some examples will be given.

In-Shift Information

The graph of face machine position has already been mentioned. An example of this is shown in Figure 3.

In addition, a log of a face's performance to date in the shift is also available.

Figure 3 - Graph of Face Machine Position



On the Tektronix located in the Deputies' Office, the current reported status of all production units may be displayed by simply pressing a button.

The machine position graphs and logs described above may also be obtained by selecting the relevant Tektronix keys.

Shift-End Information

At the end of each shift a printed report is produced summarising performance. This includes a completed log for that shift.

An example of the report is shown in Figure 4.

Figure 4 - End of Shift Report

BENTLEY COLLIERY FACE PERFORMANCE SUMMARY 1/ 3/79

SHIFT	CUTS	PLOUGHS	SALEABLE ESTIM.	METRES CUT ACT	METRES CUT BUDG	PROD. INDX.	DELAY (MIN)	MANPOWER ACT.	MANPOWER BUDG.
D34 DAYS	1.00		188.	154	396	39.	207	8	8

FACE SHIFT LOG

FACE D34 DAYS 1- 3-79

TIME PERIOD		STOOD (MINS)	CHOCK NO.	CATEGORY	CAUSE
6: 0	6: 0	0	34		
6: 0	7:10	70	34	OTHERS	SHIFT CHANGEOVER
7:10	9:32	142	34	GEOLOGICAL	ADVANCE CHOCKS IN BAD GROUND
9:32	9:40	0	0		
9:40	9:40	0	0	FACE ENDS	M.G.-TURNROUND
9:40	9:50	0	40		
9:50	10: 0	10	40	FACE ENDS	M.G.-SUPPORTS
10: 0	10:20	20	40	OTHERS	SNAP TIME
10:20	10:50	30	40	FACE ENDS	M.G.-TIMBERING UP OVER CHOCKS
10:50	11:45	0	122		
11:45	12:10	25	122	AFC	RE-GRADE PANS LIFTING AFC
12:10	12:10	0	122	OTHERS	SHIFT CHANGEOVER

The headings of this report are:

1. Unit identification
2. Number of cuts made
3. Number of ploughs made
4. Estimated saleable tonnes (This is based on standard tonnes per cut and face length figures held in the computer. These are up-dated as and when they change.)
5. Metres cut (This being required for the Incentive Scheme monitoring - described later.)
6. Budget metres cut (This budget figure being the metres required to be cut for each man to achieve standard task - as defined by the Incentive Agreement for the Unit.)
7. Productivity index (This is a measure of the efficiency of the performance per man deployed.)
8. Delay - minutes (This is the total delay time reported during the face available time, excluding snap time.)
9. Manpower (The budget is the planned manning level, and the actual refers to the number deployed that shift.)

Currently this report is being extended to include ripping performance, actual depth of cut, and identification of unreported stoppages.

The lower part of the report shows an example of the complete face-shift log with detail of time, machine position and activity.

Eleven copies of the report are produced automatically on the Dec-writer and distributed to the management team, those for the dayshift at 1.00 p.m., and for the other shifts the next morning.

Day-End Information

A colliery summary showing production and manning details together with percentage of target achieved on each face, and the run-of-mine tonnage for the day is produced on a daily basis. An example of the report is given in Figure 5.

This report may be produced at shift-end if required.

Longer Term

A facility is available for an analysis to be made of stoppages to any face over any time period.

The user is free to choose:

(i) The face
(ii) The time period

BENTLEY COLLIERY FACE PERFORMANCE SUMMARY 20/ 4/79

SHIFT	CUTS	PLOUGHS	SALEABLE ESTIM.	METRES CUT ACT	METRES CUT BUDG	PROD. INDX.	DELAY (MIN)	MANPOWER ACT.	MANPOWER BUDG.
D10									
DAYS	0.75	0.00	113.	118	310	38.	227	16	18
A/NOONS	0.75	0.00	113.	118	233	51.	220	12	18
NIGHTS	0.50	0.00	76.	79	174	45.	210	9	18
ALL	2.00	0.00	302.	315	717	44.	657	37	54
D14									
DAYS	2.00	1.25	444.	416	365	114.	120	18	19
A/NOONS	1.00	2.00	222.	208	324	64.	135	16	19
NIGHTS	2.00	1.25	444.	416	284	146.	230	14	19
ALL	5.00	4.50	1110.	1040	973	107.	485	48	57
D34									
DAYS	1.00		188.	154	396	39.	217	8	8
A/NOONS	1.50		282.	231	347	67.	235	7	8
NIGHTS	0.75		141.	115	396	29.	132	8	8
ALL	3.25		611.	500	1139	44.	584	23	24

	SKIPS WOUND	ROM TONNES
DAYS	134	1005.0
A/NOONS	137	1027.5
NIGHTS	105	787.5
ALL	376	2820.0

Figure 5 - Day-End Summary

(iii) The time limit. Only delays of greater duration than this are considered.

(iv) Whether or not stoppages over all shifts or just specific shifts are required.

(v) Whether the analysis covers:

- all categories and cause of stoppage
- just a specific category (e.g. all main machine stoppages)
- just a specific category and cause of stoppage (e.g. main machine - rack-a-track)

(vi) Whether only stoppages relevant to a specific department (e.g. mechanical or electrical) are required, or all departments.

Cumulative production totals and manpower, machine shifts worked, and percentage of target achieved over any time period on any face may also be produced.

Examples of these reports are given in Figures 6 and 7.

Figure 6 - Delay Analysis

DELAY ANALYSIS

1 MAR 79 - 7 MAR 79
SHIFTS CONSIDERED= DAYS
ALL CATEGORIES OF DELAY
ALL CAUSES OF DELAY
DELAYS GREATER THAN 20 MINUTES

D34 FACE

CATEGORY	CAUSE	NO OF OCCS	TOTAL DURATION
NO. 1 MACHINE	CABLE HANDLER	1	23
GEOLOGICAL	ADVANCE CHOCKS IN BAD GROUND	1	142
SUPPORTS	ADVANCE CHOCKS	1	85
FACE ENDS	M.G.-TURNROUND	3	137
FACE ENDS	M.G.-TIMBERING UP OVER CHOCKS	1	30
FACE ENDS	T.G.-TURNROUND	4	128
AFC	TIGHT TRACK	1	20
AFC	RE-GRADE PANS LIFTING AFC	1	25
GATE BELT	REPAIR JOINTS (BUCKLES)	1	25
GATE BELT	MATERIALS RUN	1	20
OUTBYE	BROKEN BELT	1	20
OUTBYE	BUNKER FEED BELT	1	22
OTHERS	OTHER STOPPAGES	1	20
			697

DELAY ANALYSIS

1 MAR 79 - 31 MAR 79
SHIFTS CONSIDERED= A/NOONS
CATEGORY REQUESTED= AFC
ALL CAUSES OF DELAY
DELAYS GREATER THAN 10 MINUTES

D34 FACE

CATEGORY	CAUSE	NO OF OCCS	TOTAL DURATION
AFC	T.G. DRIVEHEAD ELECTRICAL	1	45
AFC	RE-GRADE PANS LIFTING AFC	1	13
			58

Figure 7 - Period Production Report

PRODUCTION SUMMARY — 3 OCT - 8 OCT 79

D10 FACE

NO OF STRIPS	NO OF M/C SHIFTS	METRES CUT ACT	METRES CUT BUDG	PROD INDX	FACE OMS	MAN SHIFTS TOTAL	MAN SHIFTS O/T
11.75	12	2092.	3149.	66.4	12.29	152	0

MAJOR STOPPAGES (GREATER THAN 5 MINUTES)

DURN		DELAY	DATE	SHIFT
14	FACE ENDS	M.G.-TURNROUND	3OCT	DAYS
30	NO. 1 MACHINE	WATER HOSE	3OCT	DAYS
15	GATE BELT	BLOCKED CHUTE	3OCT	DAYS
60	NO. 1 MACHINE	WATER HOSE	3OCT	DAYS
25	SUPPORTS	ADVANCE CHOCKS	3OCT	DAYS
5	SUPPORTS	IRON BOUND	3OCT	DAYS
15	NO. 1 MACHINE	MACHINE FAST	3OCT	DAYS
60	OTHERS	DISPUTE DURING SHIFT	3OCT	A/NOONS
60	AFC	RAM PLATES	3OCT	A/NOONS
35	FACE ENDS	M.G.-TURNROUND	3OCT	A/NOONS
125	FACE ENDS	M.G.-TURNROUND	3OCT	A/NOONS
188	STAGE LOADER	CHAIN OUT OF RACE	3OCT	NIGHTS
15	NO. 1 MACHINE	WATER HOSE	3OCT	NIGHTS
10	FACE ENDS	T.G.-TURNROUND	3OCT	NIGHTS
20	SUPPORTS	ADVANCE CHOCKS	3OCT	NIGHTS
26	SUPPORTS	CLEAN OUT CHOCKS	4OCT	DAYS
18	SUPPORTS	ADVANCE CHOCKS	4OCT	DAYS
30	SUPPORTS	ADVANCE CHOCKS	4OCT	DAYS
30	FACE ENDS	M.G.-TURNROUND	4OCT	DAYS
35	FACE ENDS	M.G.-TURNROUND	4OCT	DAYS
17	SUPPORTS	ADVANCE CHOCKS	4OCT	DAYS
8	SUPPORTS	ADVANCE CHOCKS	4OCT	DAYS
10	SUPPORTS	ADVANCE CHOCKS	4OCT	DAYS
155	OTHERS	WORKING FACE END(S) ONLY	4OCT	A/NOONS
125	FACE ENDS	T.G.-FACE END BEHIND	4OCT	A/NOONS
165	OTHERS	WORKING FACE END(S) ONLY	4OCT	NIGHTS
115	OTHERS	WORKING FACE END(S) ONLY	4OCT	NIGHTS
13	FACE ENDS	T.G.-TURNROUND	5OCT	DAYS
12	OUTBYE	BUNKER FEED BELT	5OCT	DAYS
55	FACE ENDS	M.G.-TURNROUND	5OCT	DAYS
10	FACE ENDS	M.G.-TURNROUND	5OCT	DAYS
15	FACE ENDS	T.G.-PUSHOVER	5OCT	DAYS
53	FACE ENDS	T.G.-TURNROUND	5OCT	A/NOONS
5	FACE ENDS	M.G.-TURNROUND	5OCT	A/NOONS
62	FACE ENDS	M.G.-TURNROUND	5OCT	A/NOONS
30	NO. 1 MACHINE	WATER HOSE	5OCT	A/NOONS
165	OTHERS	WORKING FACE END(S) ONLY	5OCT	NIGHTS
115	OTHERS	WORKING FACE END(S) ONLY	5OCT	NIGHTS
37	NO. 1 MACHINE	T.G. MACHINE TO CUT BUTTOCK	6OCT	DAYS
28	AFC	RE-GRADE PANS LIFTING AFC	6OCT	DAYS
83	NO. 1 MACHINE	T.G. MACHINE TO CUT BUTTOCK	6OCT	DAYS
10	FACE ENDS	T.G.-TURNROUND	6OCT	DAYS
22	SUPPORTS	ADVANCE CHOCKS	6OCT	DAYS
43	FACE ENDS	M.G.-TURNROUND	6OCT	A/NOONS
22	SUPPORTS	FAULTY CHOCKS	6OCT	A/NOONS
10	SUPPORTS	ADVANCE CHOCKS	6OCT	A/NOONS
10	FACE ENDS	T.G.-PUSHOVER	6OCT	A/NOONS
70	FACE ENDS	M.G.-TURNROUND	6OCT	A/NOONS
165	OTHERS	WORKING FACE END(S) ONLY	6OCT	NIGHTS
115	OTHERS	WORKING FACE END(S) ONLY	6OCT	NIGHTS

2561 TOTAL

ALL REPORTED DELAYS,TOTAL DURATION=25[illegible]4 MINUTES

The system has recently been extended to cover:

(i) Development performance

(ii) Details/specifications needed for immediate re-ordering, on failure, of any item of equipment on a production unit.

(iii) Delay trends over any period up to a maximum of 13 weeks.

A data bank is being created which will eventually enable additional long-term trends to be detected.

USES OF REPORTS

All relevant discussions between the colliery manager and the other members of the management team are centred around the end-of-shift summary. All weekly and monthly meetings that discuss production detail also use the information derived from the computer - in this case the delay report.

Delay detail can be quickly and automatically extracted for an individual delay type (or alternatively all types of delay), e.g. detail of A.F.C. delays on an installation since the change may be required. In this case the printout will show the frequency, duration and total delay caused.

The expected life of machinery can be determined from such a log.

Machine gearboxes, haulage ends, etc., may be treated similarly, and providing conditions of use remain stable a comprehensive log of performance of equipment can be determined.

It is recognised that in a broad sense a form of Method Study assessment of machine performance can very quickly be created by taking turn-round times, time taken to cut, plough, operational delays and efficiency. These can be averaged over as many cycles as required and over any time period since the system was commissioned.

Incentive Scheme

During the pre-installation period a national incentive scheme was introduced. Broadly the basis is extra pay over and above the day wage for output beyond the agreed norm. In addition payment is made when certain types of delay exceed 20 minutes. The computer-based information system has proved to be invaluable for eliminating disagreements over these payable delays.

First, the shift log is checked against the Deputy's time sheet. Any difference in time is adjusted to the log and any delay payable as interruption to work agreed and initialled. Delays not payable under the incentive agreement are eliminated and the reason noted. The logs are kept and at the end of the week, the information is provided to the face team. Any discrepancy between this information and what the team expects can then be discussed and agreement reached.

Faster Re-ordering

The computer system now holds information on the major parts of the mechanical equipment used on each production and development unit and this reduces the delay in re-ordering. Each part's name, number, NCB vocabulary number, central store location and bin numbers can be displayed on the Tektronix in the Control Room. A typical display for the crawler tracks for development machines at the Colliery is shown in Figure 8. Thus the engineers have immediate access to this information so that the re-ordering process can begin straightaway.

EXPERIENCE WITH THE SYSTEM

Basing the management information system upon a secondary computer has proved to be a success. The flow of information has improved and management at all levels use the reports and request information from the system. The Control Room operators are keen on the system and have adapted well to it. They can become fully conversant with it within one week. Any occasional user can interrogate the data files to produce a report with a few minutes' instruction.

Figure 8 - List of Spares for a Development Machine

<<< PARTS >>>

COLLY : ROADHEADER/DINTHEADER TRACKS (ALL HELD AT ALLERTON BYWATER)

	PARTNAME	PART NO.	VOCAB	LOCATION
1	CRAWLER CHAIN ASSEMBLY	BD308000A	15/61/5669/0000	AB13163/4/5
2	CHAIN SHOES	SB402301A	15/63/0283/0005	AB05000
3	LINK PIN	TB202002A		OUR STORES
4	TENSION UNIT	BD807000A		PLANT POOL
5	JIB SUPPORT WEAR RING	CE47585A		U/G STORES
6	CHECK VALVE EXACTOR	90195	15/62/4718/0003	83201
7	140 HP GEARBOX	BD 809040		PLANT POOL
8	COUPLING ASSEMBLY	BD809002	15/62/5702/0008	13154
9	SUCTION HOSE 1.25"	BD823001	15/62/9764 0005	82965
10	SUCTION HOSE 1.50"	BD823002	15/62/9765/0004	82941
11	SUCTION HOSE 2.50"	BD823003	15/62/9766/0003	83202
12	CRAWLER ENGINE	XSB403200		PLANT POOL
13	TENSION UNIT	XSB413300		PLANT POOL
14	TRUNK LIFTING CYLINDER	XSB421000	15/63/8310/0005	OUR STORES
15	ARCING CYLINDER ASSEMBLY	XSB420000		OUR STORES
16	CUTTING HEAD ASS P F F	XTB210100A		PLANT POOL
17	SCRAPER C/V HYDRAULIC MOTOR	XSB414000		PLANT POOL
18	COUPLING	XSB414031	15/63/8221	13134
19	RUBBER DISC		15/61/5645	13134
20	SCRAPER C/V TENSION CYLINDER	HM62496	15/62/4186/0006	13134
21	BREAKER BAR PLATE	CE46938	15/62/8438 0003	81617
22	BREAKER BAR PLATE	CE 46939	15/62/8439 0002	81541
23	JIB HEAD SHAFT SPROCKET	CE 46164	15/62/8165 0002	80163
24	KEYS	CE46164	15/62/8164 0003	82734
25	CONNECTING LINK	CE8853	15/62/6353 0008	83296

Two major extensions are now underway. First of all this manual-input system is being integrated with the automatic data capture system developed by M.R.D.E. Secondly, the feasibility of a computerised manpower deployment scheme has been established and work has just begun upon its installation.

LESSONS TO BE LEARNED

There are a number of lessons to be learned from the experiences at Bentley Colliery.

1. The principle of client-orientation has proved to be fundamental in obtaining management's enthusiasm and co-operation.
2. Development and modification of the system has always been a co-operative venture between management and the technical personnel. This has led to mutual understanding of the problems involved in creating a computer-based system that will actually be used by management.
3. Successful implementation of the system undoubtedly benefited from the 24-hour coverage provided by the technical personnel during the installation and training period.
4. Valuable experience has been gained by management in the use of computer-based information paving the way for a system using automatically-captured data. It is true to say, however, that further experience and training is necessary if the fullest use is to be made of the system by management, and if long term analysis of information and trends in the data is to be successfully interpreted.

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THE UTILIZATION OF MATHEMATICAL METHODS AND COMPUTERS IN THE IMPROVEMENT OF PLANNING IN THE POLISH HARD COAL MINING INDUSTRY

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1. INTRODUCTION

The dynamic increase in the output of hard coal in Poland is achieved by introducing into mines up-to-date techniques and technologies and by modernizing of the existing collieries as well as constructing new ones. That is why the planners have to face the problems concerning the continuous improvement process of the actual forms and methods of management. Permanent improvement of planning that is achieved by wide spread usage of scientific methods of decision optimization becomes a matter of special importance. Great possibilities are offered by the application, for planning purposes in the coal minig industry, of computer techniques and already tested methods in the field of operation research, such as network analysis, linear programming and simulation and also modern methods of econometric forecasting.

The first steps of a wide range utilization of these methods in planning were udertaken in the Polish coal mining industry in the sixties. They have been initiated mainly by the previous Centre of Economics, Organization and Computerization of the Central Mining Institute.

Within a period of 1963-1966 as a result from a broad training action among the managerial staff of enterprises in the coal mining industry, several attempts were made to apply the PERT method for planning and control in the realization of investment and production undertakings in collieries, mining construction enterprises and in mining machinery works [20].

Single attempts of using in hard coal mines the so called selection procedure algorithm for distribution of production at sections and faces which developed in UK, have been made in the years 1966-1969 [3]. At that time the linear programming method was competetive to the selection procedure used for solving these problems.

Contrary to the selection procedure the linear programming method was applied for determining the working schemes at given faces and sections by means of a computer [4]. Basing on the computer techniques and linear programming method it became possible to carry out the study research on the perspective development of coal mines on the mining industry scale [11].

By the end of the fifties the carried out research works have shown the usefulness of the regression models usage in forecasting for the purpose of planning the production activity and the coal mine investment [9].

Later on this studies have created also the basis for joint usage of the simulation method and the regression analysis

for the purpose of the economic efficiency evolution of the planned undertakings [12].
The gained experiences in the field of operation research application for planning in the hard coal mining industry have shown that the high labour - consuming process of data aquisition made their propagation impossible.
Quite often the problems of evaluating proper values of input data basing on the running accountancy have occurred. This resulted mainly from the shortcomings of statistical information within the traditional system, which has not assured the observation of attained results in the production and investment activity according to conditions of its operation.

Permanent application of the above mentioned operation research methods in the Polish mining industry was made difficult due to the complexity of data preparation according to the required, by appriopriate computer optimalization program packages forms.
It was also difficult because the output sheets have been printed by the standard program packages in a forms that were not suitable for the majority of the users.

The essential progress in the computer application and research operation methods for planning problems was attained as a result of works, originated at the end of the sixties, on the MODEL OF COMPUTERIZED MANAGEMENT SYSTEMS IN THE HARD COAL MINING INDUSTRY [10], [17].

Due to the mutually integrated analytic-accounting and planning systems and the usage of modernized book-entries and recordings in the analytical-accounting systems and also due to the implementation of essential improvements in methods and techniques of the perspective, medium-range and operational planning of production investments, material supplies etc. it was possible to create in the model conditions for the permanent utilization of mathematical methods and computers in the planning practice of the coal mining industry. The functional scope and the basic solutions as well as the mathematical methods used in the planning systems which form the MODEL OF COMPUTERIZED MANAGEMENT SYSTEMS IN THE HARD COAL MINING INDUSTRY have been characterized in this paper.

Special emphasize was laid to those systems in which the best progress was obtained within the range of substantial solutions and by their implementation into industrial practice.

It is worth to mention that the solutions described in this paper are the result of works carried out by a big group of research workers which profit by the help of many specialists from pilot mines and coal mine areas.

2. PRINCIPLES AND BASIC SOLUTIONS ADOPTED IN THE COMPUTERIZED PROGRAM OF THE PLANNING ACTIVITY IN THE POLISH HARD COAL MINING INDUSTRY.

For the purpose of the computerized planning activity 15 big computer systems have been distinguished in the MODEL OF THE COMPUTERIZED MANAGEMENT SYSTEMS IN THE COAL MINING INDUSTRY /fig.1/.

Within the management process, they fulfil - in general - two basic functions in the decision cycle, viz. [15]:

1° - Efficiency forecasts on different variants of the intended activity within the field of production; investment, auxiliary and service facilities in the coal mining industry.

2° - Performing, under the considered variants, such a selection which, on assumed conditions and criteria will assure an optimum economic effect.

These systems are integrated both among themselves and with other 20 analytic-accounting systems. The task of the last systems is to exercise two remaining basic functions in the decision cycle with regard to the event recording and current evaluation of the operation efficiency. In this way the planning systems together with analytic-accounting ones, incorporated in the MODEL, create conditions in which the computerization covers the whole decision cycle connected with production, investment auxilliary and service activity within the coal mining industry. The MODEL comprises all levels and phases of management from data collecting and analysis of a sufficient amount of source data to decision making and control of their realization.

For achieving the highest management efficiency the following rules have been applied in the systems of planning activity computerization [15], [17].

1. Setting production and investment plans on the basis of multi variants planning offers the coal mines tender for production assignments and resources for their accomplishment.
2. The usage of advanced planning is based on the cyclic updating of plans and keeping the time horizon as a constant value.
3. The usage of identical for all planning offers, forecasting methods of the evaluation of their economic efficiency.
4. Inseperable elaboration of production and investment plans for all mines in one integrated procedure of investment and production efficiency evaluation.
5. Making an optimum choice of planning tender sets from the viewpoint of all-branch criteria and conditions.
6. Setting production and investment plans in such a way and so detailed that they could be treated as a basis for operating the auxiliary and service activity planning systems which contain investment execution, material, machine and device supply, employment etc.
7. Elaboration of plans for the auxiliary and service activity based on the application of variant solution methods, which enable to present solution sets with a given provision to the highest economic efficiency.

In order to create conditions for full introduction of the above mentioned seven principles which improve the basic elements of the previous planning procedure into the mining industry practice several detailed system and designprogram solutions as well as solutions concerning the usage of appriopriate mathematical methods have been used in the MODEL OF COMPUTERIZED MANAGEMENT SYSTEMS. The main of them are [15] , [18]:

1. The application in the analytical-accounting systems of modern book-entries, recording and clearing methods, assuring not only the profoundness of the internal self-accounting system, but also giving the universal information base for the purpose of prognostic methods of decision efficiency and optimization that are used in the planning systems. Special attention is paid on the individualized observation method of elementary economic proceedings, which enables the recording and settling of expenditures with regard to different the technique and production technologies.

2. Creating in the analytical-accounting systems highly efficient information banks, equipped with univeral packages of programs, which make possible of getting such information and analysis sets, which are not only useful for improvement of the current management, but also - what seems to be more important will "prompt" the planning services with appropriate variants of planning offers .

3. Application of similar as in the case of analytic-accounting systems, such design - program solutions, which enable the implementation and operation of particular systems,

subsystems and sections or modules both in connection with other systems/subsystems, sections or modules/ and independently. These solutions have a remarkable significance for the realization of the idea in step by step implementation of the computerized planning activity in the coal mining industry. The solutions allow for carrying out the works by stages and for selective choice of computerization.

4. Progressive "introduction" of improved, and quite often more difficult /which require more computer time/ balancing, forecasting and decision optimization methods into particular systems.

5. Application of solutions enabling automatic generation of optimized models by means of a oomputer /for example automatic generation of linear programming matrices, detailed networks and activity data in case of the PERT method etc./ and the automatic flow of statistical data, from analytic-- accounting systems, which are indispensable for creating and updating econometric models /e.g. regression equations/ which have been assumed for the forecasting purpose.

6. Application of objective, scientific forecasting methods /e.g. methods of regression analysis, simulation, analyses of time series/ and of decision optimization /e.g. linear programming, PERT method/.

7. The design, within the framework of particular systems, of magnetic files, containing a catalogue of typical planning elements with full technical and technological data /e.g.

files with catalogues of typical development works together with such information like: shift progress, number of working hours per day, indispensable resources for carrying out a given job etc./.

8. Replacing standard prints of optimized program packages by output sheets in a form and contents adopted to requirements and interpretation abilities of users on different management levels.

9. "Transfer" of all the most labour-consuming planning functions, connected, for example, with the predicted evaluation of the economic efficiency of planning variants, balancing, forecasting the volume of needed resources, recording of planning reports etc.

Although the introduction of many mentioned principles and solutions into the management practice is extremely difficult, it seems, that their performance can and should lead to quality changes, both in manners and planning methods throughout the Polish hard coal mining industry.

3. FUNCTIONAL RANGE OF COMPUTERIZATION SYSTEMS OF PLANNING ACTIVITY

When realizing the principle of computerising by stages / in accordance with the adopted priorities/ planning of all kinds of activities of the coal mining industry 3 groups of planning systems were distinguished in the MODEL, namely:

- planning systems of production and investment, which realize forecasting the effectiveness and optimation of long-range, five-year and annual plans of production and investment activities of coal mining industry,
- planning systems of auxiliary activity which include operational planning of production and development work in hard coal mines, central many years planning of fundamental investments realization and executive potential and short-term operational planning in the scale of enterprises and areas of building-assembling and mining work,
- planning systems of service activity which computerise planning of remaining economy fields managed, as a rule, by specialized central organization units of the coal mining industry.

The tasks performed in the management process by particular systems entering into the composition of the mentioned, three groups are as follows[x/]:

A. Planning systems of production and investment

1. System of long-range planning of mines construction and development /SPP/.

- Forecast of economic effectiveness of construction and development of mines variants from the viewpoint of all-branch criteria.

[x/] The description of tasks of individual planning systems was taken from [17].

- Forecasting of productive and economic effects of branch development and setting of long-range realization schedule of indispensable investments.

2. <u>System of five and one year planning of production and modernization of mines</u> /SPK/

- Optimum /from the viewpoint of all-branch economic criteria/ allocation of production in individual seams together with the choice of extraction technology and pointing to the most effective modernisation investment in particular mines and panels.

- Distribution between particular mines of the most effectiv equipment which due to the limited attainability is being dispensed through an all-branch "allocation by tender".

B. Planning systems of auxiliary activities

1. <u>System of operational planning of production in mines</u> /SPO/

- Optimation of operational plans of shift system of work at faces and of amount of personnel in the principal professional groups servicing technological lines.

- Evaluation of the output volume attainable as result of application in existing production lines of new face equipment and the increase of the amount of personnel in particular professional groups.

- Planning analysis of variants in the development of production front.

2. <u>System of operational planning and control of the development works</u> /SPO-RP/

- Fixing and updating every month the manning and equipment plans and time scheduling of development and modernization works jobs according to their advancement in the past month and also the attained in this time progress of production faces - allowance being made for availability of resources /employment, equipment etc./.

3. <u>System of central planning of investment realization and executive potential</u> /SYSPRI/

- Annual and five-year planning of investment outlays,

- Central distribution of investment executive potential for particular undertakings, tasks and investment projects assumed in the annual and five-year investment plan.

- Simulation analysis and assessment of effects which are to be anticipated in the case of increasing or reducing the potential of particular execution sectors /change of dates of putting into operation the investment projects, influence of such changes on the production volume etc./.

4. <u>Short-term planning of jobs in the investment execution</u> / SOPR /

- Balancing the jobs assumed for realization in annual plans.

- Short-term planning of demand for basic resources necessary for investment realization,

- Fixing and updating every month the manning and equipment plans and the time scheduling of requirements jobs concerning the projects according to investment plan and principles of rational management of equipment and human resources.

C. Planning systems of service activity

1. System of central planning of spares economy for mining machinery and equipment /SCGZ/

- Forecasting of consumption and preparing supply plans by assortments of spare in particular quarters of the nearest planned year.

- Correction of the plan of spare supplies in particular quarters of the planned year.

- Long-term forecasting of consumption and preparing long-term optimised plans of spare supplies.

2. System of central planning of supply with basic mine equipment /SCGW/

- Assessment of the state of usefulness of the available equipment from the viewpoint of scrapping policy.

- Variant assessment of possibility and effects of supplying mines with new types of machinery and equipment allowing for processing capacity of factories and profitability of overhaul of the actually utilized equipment.

- Demand forecasting and optimum purchase plan of mine equipment in engineering works together with the plan of withdrawal of obsolete and introduction of new equipment types.

3. System of overhaul policy planning /SCGR/

- Planning and monitoring of overhaul jobs carried out for hard coal mines.

- Assessment of the processing potential of repair shops together with prognostic evaluation of effects of engaging this potential for overhaul of equipment.

- Forecasting of demand for economically justified overhaul services and drawing up the optimum overhaul plan.

- Planning of technical preparation of overhaul production in the central repair shops.

4. System of central planning of coal sales and deliveries /SPZW

- Forecasting of the demand for coal with its consumers with allowance for development of technique and increase of effectiveneas of coal utilization.

- Optimation of the plan of coal deliveries, its transport and reserves being at consumers and mines.

5. System of central planning of material supply in the coal mining industry /SPZM/

- Prognostic balancing with reserves for material demands for nearest year.

- Optimation of the plan of centralized orders for materials and the schedules of their delivery together with optimation of the extent and scope of activities of the network of central, district and mine stores.

- Long-term forecasting of material consumption.

6. System of central planning of employment wages and staff development /SCGK/

- Forecast of the size of employment required for implementation of the plan of production in the nearest year and five-year period having regard to the anticipated introduction of technical and organization progress.

- Prognostic balancing of demands in the scope of employment with the anticipated employment in the nearest year and five-year period.

- Optimation of the plan of making up the employment.

7. System of planning of variant solutions in the scope of production investments /SPMT/

- Current assessment of economic effectiveness of commissioned underground modernization investments toghether with comparative analysis of efficiency of the design and constructio solutions used.

- Selection for investors and design offices of - under the given conditions - the most effective design and construction solutions as a basis for drawing up variants of modernization investments.

8. System of planning forecast and effectiveness control of research, development and implementation works /SPBW/

- Forecasting of cost and effectiveness of products of research and development works together with revision of the worked out forecasts after completion the research and development phase.

- Planning control of economic effectiveness of research and development problems, subjects and tasks as well as of institutes and organisation units implementing these works.

9. <u>System of planning of finances and exporting services</u> /SUEF/

- Forecast and plan of the extent of demand for particular kinds of funds with regard to the sources of their financing.

- Forecast of demand of the foreign countries for services rendered directly by the mining sector together with the plan of their implementation in the nearest year and the five-year period.

Source data indispensable for realization of the mentioned functions are attained by planning systems primarily from analytical accounting systems. Flow of information between individual systems is presented on fig. 1.

In further sections the attention has been focussed on the most important solutions adopted in the planning systems of production and investment as well as in fundamental systems of planning auxiliary activities i.e. in systems in which overwhelming majority of problems having the most essential influence on the effectiveness of management in the coal mining industry are being determined.

4. SYSTEM OF LONG-RANGE PLANNING OF CONSTRUCTION AND DEVELOPMENT OF MINES /SPP/

The range of tasks presented in the precedent section, falling to the SPP system is realized in two succeeding stages [13] .

In the first stage technico-economic assessment of effectiveness of variants of construction of new mines and reconstruction, maintenance and liquidation of operating mines is realized by means of the program package of the SPP.1 subsystem. In the second stage the selection of the sets of variants of optimum mines, from the viewpoint of all-branch criteria and conditions, is made by means of the program package of the SPP.2 subsystem. The scheme of functioning of SPP.1 and SPP.2 subsystems in the process of determining plans of the branch development is ilustrated in fig.2.

The technical design conceptions of the future development of production and inwestment activity of mines are a basis of determining the economic assessment of variant effectiveness of mine perspective development what is carried out by means of the SPP.1 subsystem [1] , [3] . It is assumed in SPP.1 subsystem that the elaboration of such conceptions belongs to mine management staff and design offices. The conception of construction and development of mines according to requirements of the system must include the scheme of development of deposit foreseen for extraction in the period covered by planning, and also information on anticipated technical level of the future exploitation. The scheme of deposit development can contain only the location of development workings without determining the time of their execution. Data on particular workings designed for realization concern only their length and cross section. As far as operating mines are concerned the development scheme must reflect also the scheme of development of the part of deposit being already under extraction.

The anticipated technical level of future exploitation is determined by a small number of concentration indices such as e.g. daily output from a single production face, capacity of mining cars, average hoisting capacity of extracting vessel, processing capacity per hour of the coal preparation plant. The SPP.1 subsystem admits that, particular conceptions could be completed with additional information essential for future development of the considered mine, if necessary. Thus limitations can be imposed on the sequence of mining if it is caused e.g. by the conditions of surface protection. Limitations can also be imposed to the number of simultaneosuly exploited production levels. The SPP.1 subsystem requires moreover from the designer the determination of the requested size of the final output and indication of the time period for which the analysis is to be carried out. Thus, the SPP system requires from the designer or planner only these data which are the result of their creative work in the designing process.

All the remaining information indispensable for making technico-economic analysis of effectiveness of mine variants is drawn by the computer from the magnetic file of the SPP system periodically updated on the basis of data obtained directly from the system of accounting and analysis of production processes in mines and the system of investment activity of in the coal mining industry (IOS and ISB systems). These files contain such data as normatives of headings driving progress, pricelists of workings execution costs in various conditions and by various technologies and also a nember of technical indices as for instance air quantity which is required to be conveyed to the mining panels per each ton of output, air speed in various workings etc.

When the variant of development of operating mine is to be analysed, the design and magnetic file data are completed with statistical data obtained directly from the data bank of system of accounting and analysis of production processes in mines (IOS system) and of the system of fixed assets economy (I-EAST system). These data concern the fixed assets of a mine, its annual production costs, volume of output and actual disposition of mining front.

SPP.1 subsystem analyse technico-economic effectiveness of mine variants by means of simulation method connected with the method of regressive forecasting [9], [12]. The elaborated simulation program package of the SPP.1 subsystem imitates in computer the process of construction and then exploitation of mines. During the simulated construction of mine the package makes successive decisions with regard to the criterion of the earliest possible attainment of output keeping of course all limitations resulting from the premises of rational exploitation of deposits. In successive determined by the user periods of time /e.g. monthly, quarterly, semi-annual periods/ examined are the needs for starting new mining panels to attain the planned output of a mine. If necessary, decisions are made concerning the development of new parts of deposit. In this case also dates of construction of particular development workings are fixed. Prior to starting the exploatation of every new mining panel the traffic capacity of transport roads and ventilation is checked up and also the possible desing limitations relating to the sequence and mutual advancement of mining panels and parts of deposit. The choice of panels for exploitation takes place on the basis of the conducted economic calculus within which the effectiveness of different decisions possible in the given situation is compared. The measure of this effectiveness in the SPP.1 subsystem oan be the indices of unit profit, unit prime costs, profitability or the index of investment outlays per one ton of output. The choice of one of these indices is each time decided by the user of the system which gives appropriate information in the order card.

Forecasting the costs indispensable for determination of the first three indices mentioned above takes place by utilization of regressive model of the production costs. The regressive model contains a set of funotions of the production process oosts in the separated technologioal cross sections. The actual values of independent variables occurring in the model are in great part determined in the simulation process. It concerns primarily such variables as output of the mine and of particular mining panels as well as variables describing the development structure i.e. length of transport roads, length of operating workings, average cross section of workings of particular kinds etc. The values of independent variables defining the technical level of design solutions are evaluated directly from design data read into the computer by means of appropriate source documents.

Fixing the foreseen size of investment outlays for equipment of the mine underground and for erection of surface projects is carried out either by means of regression function of fixed assets or by analytical method. In the latter case the advantage is being taken of unit indices of investment outlays written in the magnetic file. The outlays for development work are, however always determined by analytical method using the price-lists of jobs contained in magnetic files of the SPP system.

Synthetic evaluation of technico-economic effectiveness of particular variants of construction of new mines and reconstruction, maintenance and liquidation of operating mines in the SPP.1 subsystem is realized by means of discount calculus.

Full technico-economic characteristics of each considered mine variant is presented in a number of results sheets containing dynamic characteristics defining the output volume in succesive years together with its disposition in particular parts of deposit, prime costs of production and running of the required investment outlays. Apart from tabular statements there are presented diagrams of production and extraction costs. There are also given the time schedules of realization of investment work and of exploitation of particular mining panels.

The optimation of the basic decisions in the scope of long-range planning of construction and development of mines is realized in the SPP.2 subsystem. For its execution, in the final phase of calculations carried out by means of programs of the SPP.1 subsystem a set is formed on the magnetic tape containing a collection of twenty five basic indices characterising in a synthetic way the technico-economic effectiveness of each of the considered mine variant. These sets of indeces concern the successive 5 year periods. The mine variants data file hold on magnetic tape are supplemented with directives of the mining industry management. The directives /split into particular five-year plans of the assumed planning period/ define the extraction tasks of the mining industry and the assumed limits, e.g. in case of investment outlays. The variants data and the directives create input data for SPP.2 subsystem [7] .
On the basis of these data the programs of the SPP.2 subsystem generate, the so-called, linear programming matrix for standard ICL XDLA program package. During the generation of the linear programming matrix additional constrains of the model are automatically created. These constrains cause that to the actually stated version of the mining industry development plan only one variant of each considered mine can be chosen.
For the designed mines additional constrains can be created assuring, by means of linear programming, the examination of

profitability of delay dates of starting their construction by five or a multiple of five-years.

The XDLA program package chooses the variants of mines for the long-range branch plan using the zero-one programming procedure. During calculations each of 25 basic technico-economic indices of assessment of mine variants can be taken into account as optimation criterion. Which index in the given run should be the basis of forming the criterion function is decided each time by the user of the system who gives appropriate information in the source document. In this document the user determines also the period for which the chosen index is to be optimised.

In the SPP system the possibility of developing few propositions of branch development plans at different sets of occuring constrains and different criteria of branch development has been anticipated. It is assumed that the updating of the long-range branch development plans by means of the SPP system will be carried out at least once a five-year period with simultaneous keeping the permanent planning horizon.

The optimation results are presented in the form of three result sheets containing synthetic information about mine variants which entered into the branch development plan and a statement of basic planning indices of the coal mining industry for the period covered by the long-range plan. Data contained in the result sheets of the SPP system facilitate the branch management to make decisions in which operating mines and according to which variant the output should be increased, in which the output should be kept on the present level and which mines and according to which variant are to be closed down. It facilitates also solving problems connected with the settlement on which mining areas, in what time and according to which variant new mines are to be constructed.

5. SYSTEM OF FIVE-YEAR AND ONE-YEAR PLANNING OF PRODUCTION AND MODERNIZATION OF MINES /SPK/

SPK System in conditions of full implementation of the COMPUTERISED SYSTEM MANAGEMENT MODEL starts the realization of its functions in the period when fundamental decisions concerning long-range development of particular mines have been already made in the SPP system. The predetermined scheme of functioning of the SPK system in the process of fixing the branch five-year and annual plans is illustrated in fig. 3.

The basic functions of the SPK system are realized on the basis of a specific "tender" of planning offers prepared by mines [5] on the branch scale. These offers concern, the so-called, planning sectors and technological links of the mine. The planning sector is a part of seam separated in the mining area and taken into account for mining in the nearest five-year period. The technological links from the point of view of the SPK system needs are elements of a simplified technological scheme presenting the main roads of coal flow from sectors to dispatching point at the surface.

In offers prepared for planning sectors and technological links the mines present variants of anticipated production /modernization/activities. Each variant is characterized by mining conditions and foreseen technical level of production realized in particular sectors and links.

In the information concerning planning sectors the mine determines particularly the following geological data: coal resources,type of coal, moisture content, ash content, calorific value. For each sector the earliest possible date of its starting is also given. This date is defined by pointing out one of the four time intervals of five-year planning period which are: first, second and third year of the five-year period and the common interval for the fourth and fifth year. Mining/technical data for each production offer of a sector includes: mining system, way of getting, kind of supports, output concentration of a single longwall in the sector, length and height of the longwall, labour consumption in the sector, intensity index of development work.

In sectors operating at the moment of data preparation the first production offer characterizes the actually used mining system. Each new offer is prepared from the viewpoint of reduction of actual production costs in the sector.
In planning sectors for which the proposed planning offers take into account the use of equipment in short supply in the scale of the branch it is necessary to prepare also offers not requiring its usage.

In the information concerning technological scheme for every link there are data prepared by mine including daily traffic capacity, length, monthly cost of its exploitation. For links which are suspected of being able to affect the output capacity the mine prepares modernization offers. Each modernization offer is characterized in the mine by the date of its realization and by the new traffic capacity of the link it concerns.

The input data to the SPK system prepared in this way by the mines is completed by branch directives. They state the requirements the plan has to meet; they concern particularly the total output of particular types of coal together with their quality parameters and the availability of machinery and equipment in short supply.

All the remaining data indispensable for carrying out the optimation calculus assumed in the SPK system can be evaluated automatically by computer. They concern the anticipated production costs of the planning offers, price of coal sale and investment outlays connected with modernization of technological links. It should be stressed, however, that the solutions of the SPK system assume also the possibility of these values being given directly by the planning services of mines.

Forecasts of production costs of particular planning sectors in the SPK system are stated on the basis of regression model of costs. As far as the operating sectors are concerned the forecasts of production costs are verified by a certain correction. The value of this correction is equal to the difference between costs estimated by means of the regression function for the past period and the costs virtually borne in this period.

It is assumed that the price of the coal sale foreseen for particular planning sectors is fixed on the basis of data obtained from the system of accounting and analysis of the production process of the coal mines (IOS system).

The investment outlays connected with the modernization of technological links are established on the basis of price--lists of mining and construction assembling jobs written in the magnetic file of the SPK system, which are created and updated on the basis of the data bank of accounting and analysis of investment activities in the coal mining industry system (ISB system).

Calculations connected with selection of the optimum set of planning offers for five-year and annual plan of the branch in the SPK system are realized by means of XDLA linear programming standard package. The linear programming matrix in the lay-out and from fully complying with requirements of XDLA package is generated automatically by the appropriate set of the SPK system own programs [6].

In the SPK system tender of the planning offers prepared by the mines is concluded on the basis of one of following criteria; minimization of production costs, maximization of production value or maximization of profit. For different pre-determined conditions e.g. for different output levels a number of optimum five-year and annual plans can be obtained. In successive versions of plans the area constrains concerning e.g. the production capacities of preparation plants servicing several mines or receipt possibilities of coal by railway junctions can be also taken into account. In the SPK system the possibility of imposing production limitations to particular planning sectors have been foreseen. These can be, for instance, requirements of attaining at least the determined output from a sector or limitations of the mining sequence in particular planning sectors.

The essential results of the SPK system are printed on six sheets which contain statements of basic indices of each plan at the level of branch, area and mines, comparative statements of indices of plans built up according to each of three optimation criteria and the comparative analysis of planning sectors.

The set of complementary information given on four result sheets is designed for stability analysis of the obtained plans at the level of branch management.

The result sheets of the stability analysis enable the assessment of influence of an unit change of constrains given when fixing the plan on the value of the optimation criterion. From these sheets, moreover, assessment of diminishing value of the optimation criterion is obtained in consequence of replacing the offers chosen for plan with those rejected in the optimation process as well as evaluation of the influence of parametrically changed values of constrains of linear model on planning indices.

6. SYSTEM OF OPERATIONAL PLANNING AND CONTROL OF DEVELOPMENT WORKS /SPO-RP/

Basing on the SPK system plans the SPO-RP system gives more detailed plan of development and modernization works for replacing the completed mining front with a new one in the coming year.
The scheme of procedure of the SPO-RP system usage for determining operational plans of conducting development and modernization jobs has been presented in fig. 4.

The tasks set before the SPO-RP system, formulated in section three, are realized by means of network analysis methods and more precisely by utilization of the ICL PERT program packages [8]. To reduce the labour consumption of preparing the input data SPO-RP system anticipates automatic generation of networks of development and modernization jobs as well as of the set of data characterizing particular activities. These networks are generated on the basis of statements of development and modernization jobs foreseen for realization in the course of the nearest 24 months and prepared by mines and on the basis of the catalogue of typical jobs.

The catalogue of typical jobs includes the statement of all typical i.e. repeatable in the scale of the branch or at least in scale of a group of mines, technologies of conducting development and modernization work together with the required for its realization unit consumption of resources. In the catalogue to each typical job is ascribed the name, identification number, number of working hours per day, progress per one month, amount of the attained output and information on admissibility of its interruption in the course of realization. The resources of realization ascribed to each typical job include the number of manshifts in total and broken up by particular professions, unit consumption of more important materials and kinds of utilized machinery and equipment. As the catalogue of typical jobs is characterized by high stability it is recordered on the magnetic file of the SPO-RP system and is only periodically updated. The user giving to the SPO-RP system the network of development and modernization jobs determines only the relationship between the jobs. The technico-organization relationship occurring during realization of particular jobs and the volume of required resources are formed automatically. In the statement of jobs foreseen for realization it is enough to assign to each job the number of typical job from the catalogue.

The data on activities concerning the development and modernization network are supplemented by the mine with information on availability of selected resources in time. Moreover, the mine makes out the statement of not limited resources whose consumption will be followed during fixing the time schedules of the jobs. In order to simplify as much as possible the process connected with carrying out the network analyses by means of a computer a set of instructions and directives for the PERT package has been prepared in the SPO-RP system and registered on the magnetic file. In these instructions three kinds of analyses have been foreseen. These are: time analysis of the project /containing all development and modernization jobs/, analysis assuming short supply of resources designed for realization of the project and analysis assuming limited time for realization of the project.

The time analysis of the project fixes the earliest and the latest dates of realization of particular activities, determines activities being there on the critical path and calculates the reserves of time or delays with regard to the directive dates of reaching some nodes pre-determined by the mine. In two remaining analyses time schedules of jobs are prepared with regard to resources needed for their realization. In consequence of the analysis assuming short supply of resources time schedules are obtained in which at the cost of possible exceeding of the required time-limits of the project execution not-exceeding of the pre-determined level of availability of the specified resources has been assured. In turn, in the time schedule made out on the basis of analysis assuming limited time of the project realization exceeding can occur in the pre-determined limits of resource availability.

In consequence of the analyses assuming short supply of resources or limited time of project realization apart from the mentioned time schedules appropriate balances of limited resources and application for the remaining resources are attained in the tabular and graphical form.

The solutions of the SPO-RP system assure also the possibility of making out for the group of mines entering into an area the synthetic statements of global consumption of particular kinds of resources. Such statements can assist the area management to shift some resources to mines where time schedules of realization of development and modernization jobs are endangered.

7. STATE OF RESEARCH/IMPLEMENTATION WORK ON COMPUTERISATION OF PLANNING ACTIVITY IN THE HARD COAL MINING INDUSTRY

Planning systems distinguished in the Model of Computerised System Management in the coal mining industry are actually in different phases of advancement of research/implementation work. It results from the adopted priorities of realization of this work and also from the scale of difficulties of substantial solutions. The relatively highest advancement of the work has been attained in plannning systems of production and investment and in basic planning systems of auxiliary and service activities.

The study and design work on the long-range planning system /SPP/ resulted in experimental implementation of simulation programs package /SPP.1 subsystem/ in 19 mines which realize the technical and economic evaluation of mine development variants. About 50 different variants of long-range mine development have been analysed by means of SPP.1 program package. This package has also been used for analysing the effectiveness of merging the mining areas of two hard coal mines.

At the same time for experimental implementation were prepared the solutions of the SPP.2 subsystem which enable choosing the optimum set of mine variants for the long-range plan of the mining branch.

In consequence of a mine request revealed in the course of experimental utilization of the SPP.1 subsystem work is actually conducted on extension of its functional range by analyses enabling making out the schedule of mining the deposit with keeping the pre-determined qualitative parameters of output such as ash content, calorific value and sulphur content.

System of five-year and annual planning of production and modernization investment /SPK/ has been brought about to the phase of experimental implementation research on the scale of mines of four coal mining areas. The implementation research includes solutions of the SPK system which makes the optimum distribution of production tasks between particular planning sectors, indicate the most effective modernization undertakings and distribute the equipment in short supply. In many cases the resulting information pointing to bottle-necks appearing in the capacity of technological production links of mines and to reserves of mining front in the five-year period has been used by areas and mines as analytical/

consulting material being the basis of advance decision making aiming at prevention of future production difficulties.

The attained progress of work on substantial solutions of the SPK system allowed in the current year for the extention of the range of its calculations by the analyses of stability of the attained production plans. The practical usefulness of the analyses is actually checked in the mines of the Rybnik Coal Mining Area.

Among all systems of production planning the largest range of implementation has been attained in the system of operational planning and control of development works /SPO-RP/. Up to now it has been applied by 52 mines. The results of the system are used for preparing the obligatory schedules of development work and as analytical material for determination of resources required for realization of this work. Most frequently mines show an interest for the system in periods of accumulation of development work or if the dates of starting new longwalls are in jeopardy.

In the range of operational production planning in hard coal mines /SPO/ the work conducted so far was concentrated on the problem of optimation of operational plans of the work shift system at faces and disposition of the personnel in mine /SPO.1/ [14] as well as on the problem of using the ICL PERT method for operational planning of development of mining front in mine /SPO.2/. From the viewpoint of the applied solutions it is worth to mention the work wich was conducted on the first of the mentioned problems. In the SPO.1 system the maximization of the average daily output of mine has been adopted as optimation criterion wich at the permanent personnel available in the given month and equipment is practically equal to maximization of productivity and minimization of unit production costs. For analysis purpose in the SPP.1 system only longwalls being in normal production have been taken into consideration.

Assignment of personnel to particular technological lines, allotment of new technology and selection of the shift system are realized in the SPO.1 system by means of original procedure being the combination of methods from the theory of reliability, gradients and linear programming. This procedure leads to maximization of output by means of such a distribution of production between particular shifts that the highest number of production shifts is ensured in longwalls with highest output and least labour consumption, and such a distribution of personnel between given technological lines as minimizes losses caused by non-utilization of available working time in faces with highest production capacities and by means of such an allotment of newly introduced equipment which guarantees its maximum utilization.

It has been assumed in the SPO.1 system that the shift output of each longwall can be defined as a product of potential output and of the so called reliability function of the technological line longwall-loading point which value depends on the personnel and equipment of the line and the employed mining technology. The potential output means the output which may be attained during the shift if there were not any disturbances in production caused by break-downs, lack of personnel and equipment and other organizational causes. The relability functions for particular technological lines are determined on the basis of statistical data concerning the shifts worked out in the service of technological lines with personnel divided on face personnel, mechanicians, electricians, carpenters and the remaining personnel and on the basis of precise information of times of breaks put in order according to causes of their formation.

The SPO.1 system has been experimentally tested in two mines. These tests have proved that this system can be effectively used only in mines provided with equipment for automatic registration of work and break-downs in technological lines as well as conducting precise record of shifts worked out on behalf of the given line. Since the principles of entering the events actually in force in the hard coal mines do not create conditions for systematic keeping such record, futher work on the development of the SPO.1 system has been suspended till to the moment of implementation in hard coal mines of an improved system of decreeing the economic events which will entail the necessity of decreeing shifts to the specific sites of their working out.

In all 153 investing units of the coal mining industry first transistory segment of the system of central planning of investment realization and excutive potential /SYSPRI/ has been implemented for industrial use. It includes planning of annual investment outlays together with the analysis of fundamental proportions of plan at the level of direct, superior and general investor. In the framework of this segment solutions for the chosen investment tasks have been started which enable direct transmission of information input relating to investment plans to the state system of central planning CENPLAN.

System of short-term planning of jobs in the investment execution /SOPR/ has been implemented for practical use in the range of two segments. The first segment /SOPR.1/ basing on technico-economic characteristics of jobs on projects presented for contracting in the planning year, blances them with the working capacities of execution enterprises and their departments making up stock of orders. It makes up also collective schedules for of investors, investment tasks, assortments of production and many plan sheets for general executers, kinds of jobs in particular quarters. The second segment /SOPR.2/, on the basis of data collected in the first segment concerning the planned material and financial scope of works and on the basis of indices of material and financial outlays per unit of production assortment calculated on the basis of statistical data from analytical/accounting systems, makes up annual and quarterly plans of costs and total employment. It draws up also the planned demand for wages fund, professional groups of personnel, heavy and medium equipment and bulk materials.

The first of the above mentioned segments of the SOPR system has been implemented on industrial scale in five enterprises and experimentally in further seven enterprises subordinate to the

Building and Assembly Division of the Coal Mining Industry. Moreover, this segment has been experimentally applied in six repairing/building plants subordinate to divisions of the coal mining industry. The second segment was applied on industral scale in three and experimentally in two enterprises of the Building and Assembly Division of the Coal Mining Industry.

Actually work is being conducted on preparation of the final version of the third segment of SOPR system. This segment utilizing the modified ICL PERT program package of network analysis will make up the most rational, under the given conditions of resource attainability, plans of realization of building assembling and mining jobs. Prooedures adopted in this segment of the SOPR system are partly based on solutions used in the SPO-RP system. It concerns especially the way of automatio generation of datailed activity networks, using the magnetic file of typical jobs and principles of using the information gathered in the system of accounting and analysis of investment activity in the coal mining industry /ISB/. As opposed to the SPO-RP system it has been assumed in the SOPR system solutions being prepared that the modified ICL PERT program package would automatically determine the most favourable technologies and shift systems of executing particular jobs /from among the previously prepared set of variants/. Making up the optimised schedules of jobs realization the SOPR.3 segment will simultaneously prepare the information input for the actually functioning SOPR.1 and SOPR.2 segments. Thus the role of SOPR.1 and SOPR.2 segments - after the implementation of the SOPR.3 segment - will be reduced to printing all-embracing balancing/planning statements [2].

Considerable progress has been attained in the system of planning management of spare parts for mining machinery and equipment /SCGZ/. Its fundamental modules which include forecasting the demands and optimation of the plan of spare parts supplies for machines for getting, loading, haulage, for powered supports, have been brought to the phase of experimental use in five factories of mining machinery, eight central repairing shops as well as in the Enterprise of Material/ Technical Turnover of the Mining Industry.

Taking into account great variety and variability in time of factors influencing the spare parts consumption in the SCGZ system a principle has been adopted of simultanecus use of a few methods of forecasting the consumption amount of the given part. The forecasts of consumption for the period of the nearest year or for longer periods are determined by means of so the called index methods while short-term forecasts by methods based on analysis of time series. In the latter case the method of exponential smoothing, Box-Jenkins method and that based on modified one-parameter Box-Jenkin's formula with automatic assessment of smoothing parameter has been mostly used. The index methods applied in the SCGZ system are based - generally speaking - on the usage of relationships arising between consumption of particular spare parts and the number of machines in operation and the volume of output attained under the given geological and mining conditions and by means of the technology used.

It seems that the SCGZ system - though containing still a number of prototype solutions - can just now contribute to the substantial improvement of the widely understood management of spare parts.

Relatively smaller advancement of work has been attained with remaining systems of planning service activity of the coal mining industry. The majority of them i.e. systems of planning supply with basic equipment of mines /SCGW/, overhaul policy /SCGR/, coal sales and deliveries /SPZW/, material procurement /SPZM/, employment /SCGK/ and planning of variant solutions in the range of production investments /SPMT/ - are in the phase of final research and design work, while systems of planning and control the effectiveness of research and implementing work /SPBW/ as well as of planning export services and financial administration /SKEF/ in the phase of conception handling. In SCGW and SCGR systems - parallelly with jobs on preparation of their final versions - work has been conducted connected with elaboration and implementation of segments and modules of these systems of the nature of introductory solutions. When discussing the state of jobs on systems of planning service activity of the coal mining industry it is worth to mention the first, prototype segment of SCGK system being in the final phase of research and designing/programming work, which realizes by means of Forrester model the forecast of employment size of mines indispensable for realization of the assumed plan of production in the nearest year and five-year period.

8. CONCLUSIONS

The state of research/design work attained in the Polish coal mining industry on computerisation of planning activity and experience gained in the course of implementation research carried out so far justify the formulation of the following conclusions:

1. Planning systems as integrated both with one another and with analytical/accounting systems and including the whole of production, investment, auxiliary and service activity of the coal mining industry create hitherto unattainable conditions for improving forms and methods of management. They enable in the planning activity the preparation of optimum decisions from the viewpoint of all-branch criteria nad conditions. Equipped with the mechanism of forecasting the effectiveness of the intended action and choice of optimum variants of solutions they allow moreover to "close" in the computer the decision cycles in all fundamental ranges of activity of mines, enterprises and the whole branch.

2. Condition of attainment the high efficiency and effectiveness of using mathematical methods in computerised planning systems is the application of solutions enabling automatic generation of optimation models and direct utilization of information contained in data banks prepared in analytical/ accounting systems.

3. Taking into account the growing role of planning in raising the effectiveness of management it is advisable to consider jobs on computerisation of planning activity as one the most urgent tasks in the complex of works aiming at improvement of management methods in the hard coal mining industry.

The works in this range should concentrate in the first place on problems of computerisation of long-range, five-year and annual planning of production and investment in thich overwhelming number of problems influencing the effectiveness of management in the coal mining industry find their settlement.

SUMMARY

The initial stage of wide utilization of computers and mathematical methods in planning were undertaken in the Polish coal mining industry in the 60's. During that time several attempts were made to apply network analyses, linear programming and simulation methods for planning purposes.

The essential progress in the field of applying computers and operational research methods for planning problems was attained as a result of work which originated at the end of the 60's on the MODEL OF COMPUTERIZED SYSTEM MANAGEMENT IN THE HARD COAL MINING INDUSTRY. For the needs of computerized planning activities 15 data processing systems have been distinguished in the MODEL and these systems are not only integrated among themselves but also with 20 other analytical accounting systems.

The planning systems of the MODEL may be divided into three groups. The first group is formed by <u>planning systems of production and investment</u>, which realize forecasting and effectiveness and optimization of long-term, five-year and annual plans of production and investment

activities of the coal mining industry. The second group consists of planning systems of auxiliary activities which include operational planning of production and development work in hard coal mines, central long-term planning of basic investments and executive potential, and short-term operational planning in the scale of enterprises and divisions of building-assembly and mining work. In the third group there are planning systems of service activities which computerize the planning of remaining economy fields normally managed by specialized central organizational units of the coal mining industry.

The authors have presented, in their paper, the functional scope of particular planning systems as well as the basic solutions and mathematical methods applied in these systems.

The solutions enabling automatic generation of optimized models are applied in the planning systems. For the needs of automatic generation the appropriate magnetic files have been designed in these planning systems. The automatic flow from the analytical accounting systems of statistical data have also been applied. Replacing the printouts of the standard optimation program packages by means of the result sheets in the form and content adopted to user requirements and the interpretation possibilities on different management levels is in common use.

The solutions of planning systems enable the transfer of the most labour consuming planning functions associated for example, with the predicted evaluation of the economic efficiency of planning variants, etc., to the computer. Planning systems distinguished in the model of computerized system management in the coal mining industry are actually in different phases of research/implementation development. It results from the adopted priorities of realization of this work and also from scale of difficulties of substantial solutions. The relative high advancement of this work has been attained in the planning systems of production and investment and in basic planning systems of auxiliary and service activities. The experiences gained from implementation show that the performance of planning systems can and should lead to quality changes, both in manners and planning methods throughout the Polish coal mining industry.

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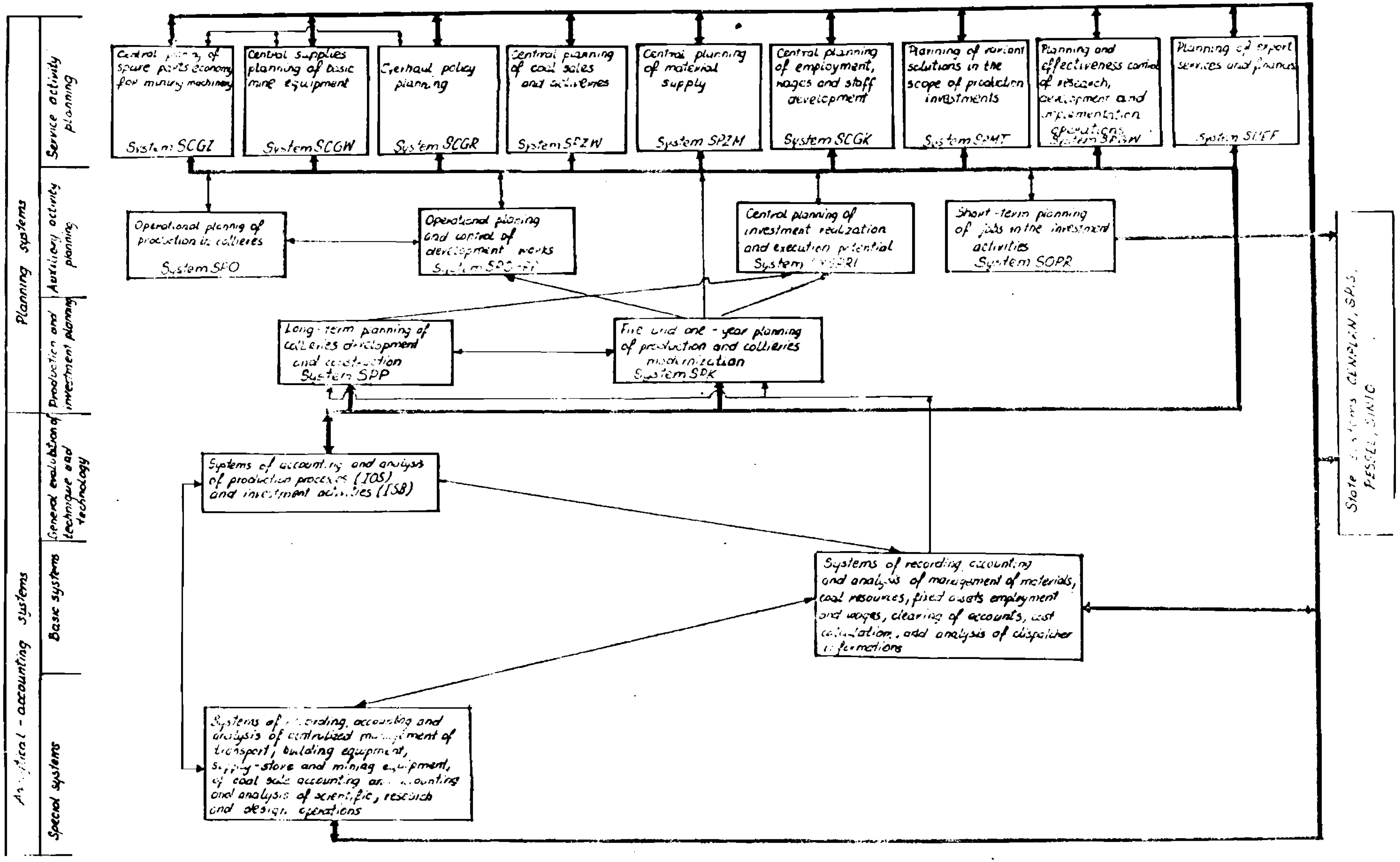

Fig 1. Place of planning systems in the model of computerised system management in the coal mining industry

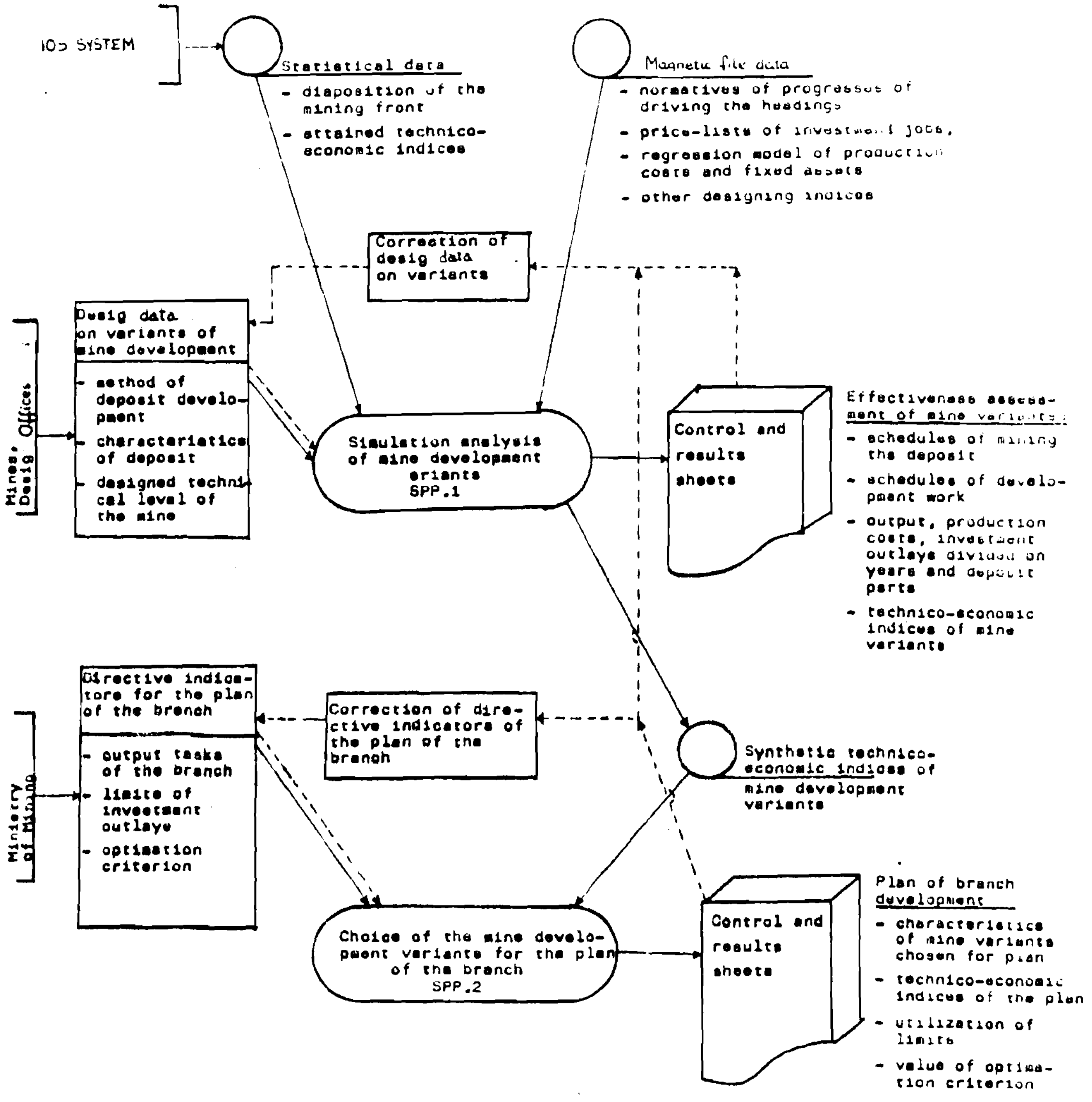

Fig. 2. Scheme of preparation of long-range plans of development of hard coal branch by means of the SPP system

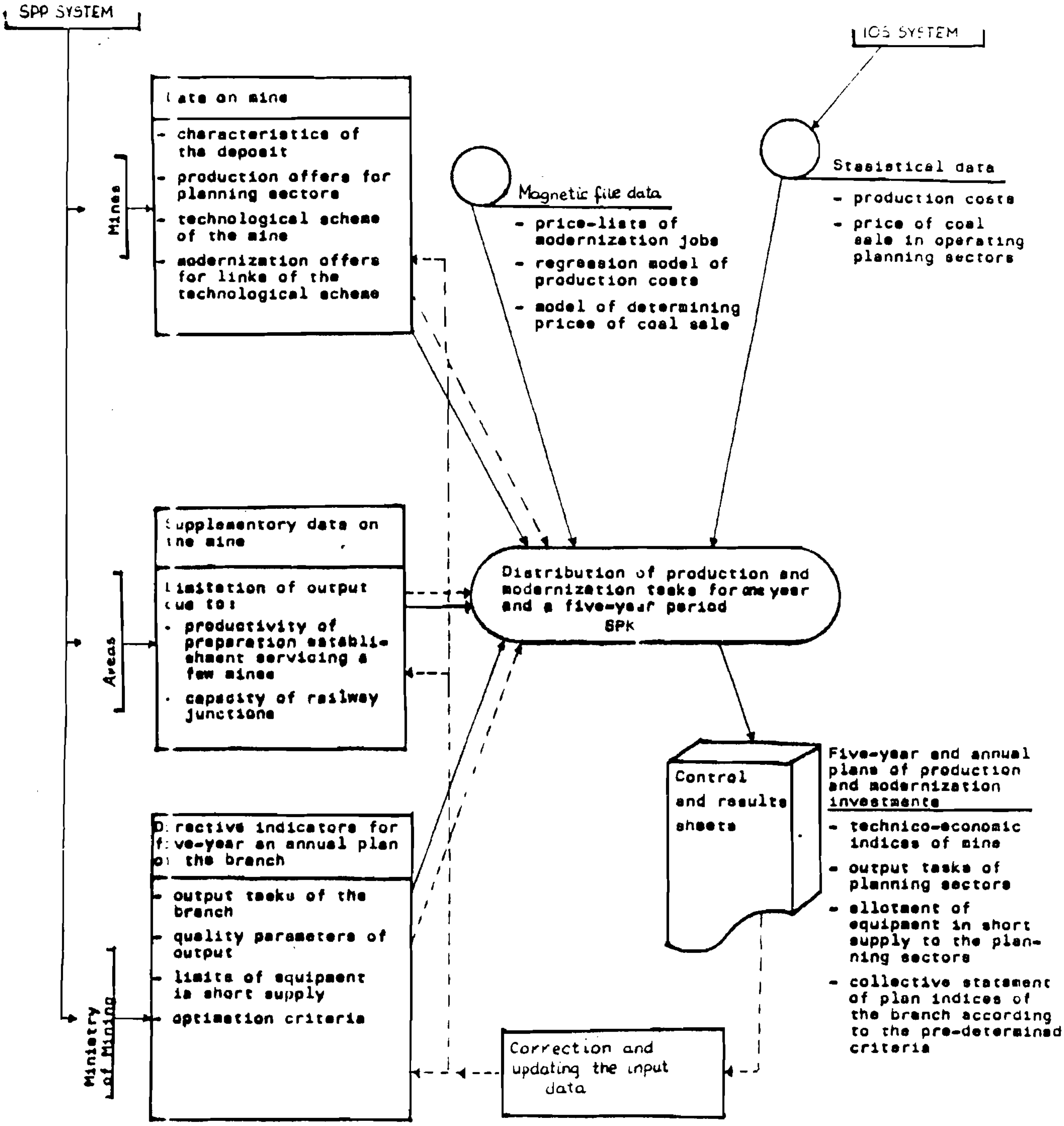

Fig. 3. Scheme of preparation of annual and five-year branch plans by means of the system SPK

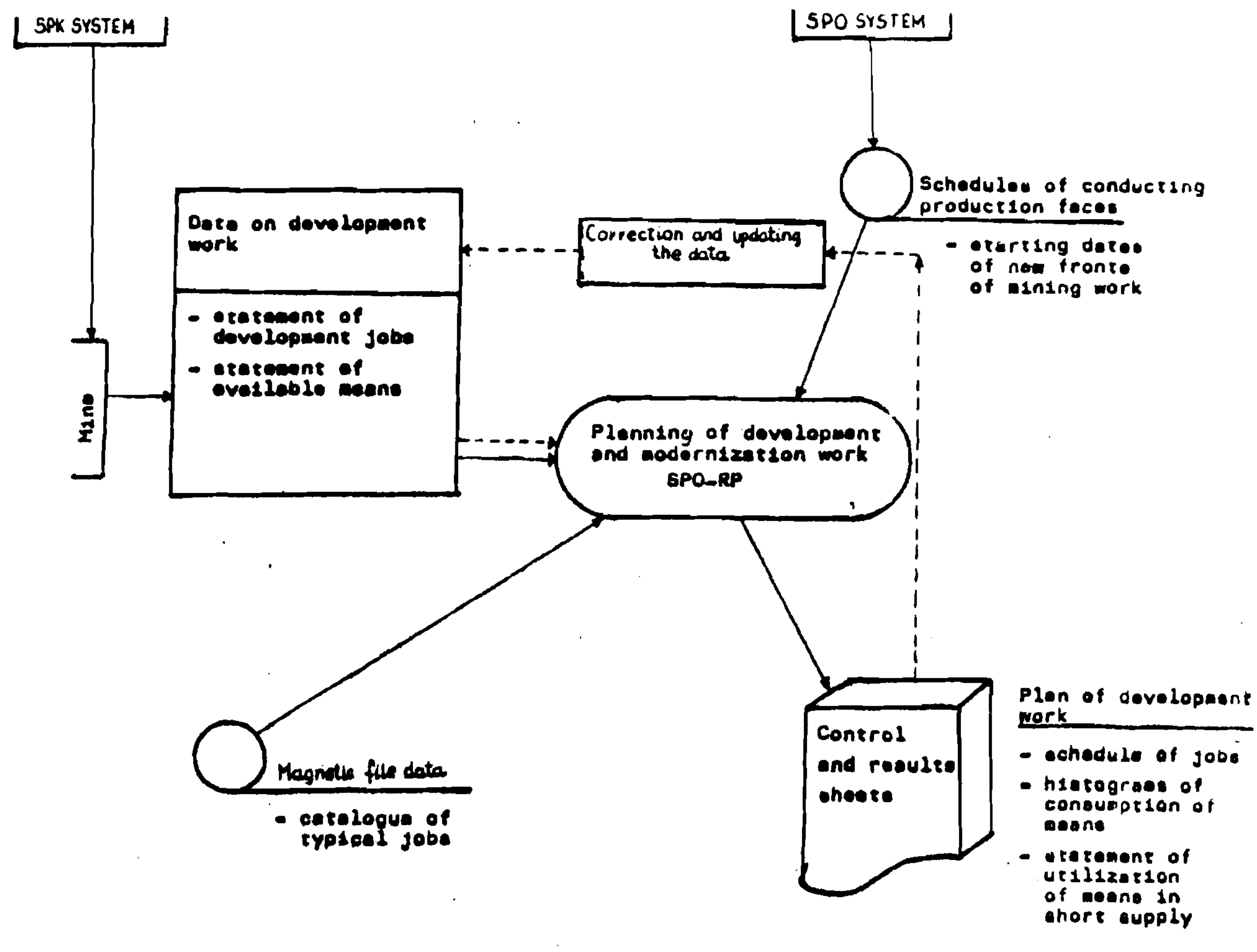

Fig. 4. Scheme of utilization of the SPO-RP system for determining the operating plan of development and modernization work in the mine