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Coal Mining Sessions

RESEARCH NEEDED—INDUSTRY VIEWPOINT

By RALPH BANKS
Safety Director, Inland Steel Co., Sesser, Ill.

Although the number of men actively engaged in the mining of coal is relatively a small percentage of the nation's working population, the coal miner and the coal-mining industry, probably more than any other single occupational group or industry, constitute a basic resource of our technological society. In addition, the economic health of this industry is literally dependent on the health and safety of the miner.

All too often the critics are not aware of the problem. Critics who point to specific flaws in the industry and urge reform are of inestimable value. I hope we are never without them, and that we will always listen attentively to what they say. But the critic we all abhor is the one who indicts our industry not because it is not trying, but because it is not perfect. This kind of criticism is irresponsible in the extreme.

Let's review briefly the importance of the coal industry to our nation.

Some things we seldom think of are that whenever a coal miner of this nation operates a machine which produces coal at a high rate, the product he produces sets in motion a flow of fuel energy which extends throughout the entire spectrum of America's industrial life. The coal thus produced: "(1) provides the fuel to produce more than 50 per cent of all the electricity consumed today in the United States; (2) provides the coke without which the great American steel industry could not have reached its preeminent position in the world; (3) makes possible the production of an abundant supply of low-cost cement; (4) is important to the production of aluminum and a wide variety of other industrial products on which is based the nation's high standard of living; (5) earns more than $500 million a year in foreign sales, thereby bolstering the nation's international balance of payments position."[1] Then there are the chemicals obtained from coal from which thousands of useful articles are made.

Coal is an old fuel, but without coal it is acknowledged this country could not meet the projected power demands, which are estimated to be seven times present consumption by the year 2000. Dr. Glenn T. Seaborg, Chairman of the Atomic Energy Commission, has stated that nuclear power, and any of the other newer sources of power, simply cannot meet the demand alone. He also said that for many decades to come nuclear power will supplement and not replace coal-produced electric power and, in fact, may never replace it.[2]

By the year 2000 it is estimated that 50 per cent of all energy consumed in this country will be in the form of electric power.

The mining, transportation, and utilization of coal mean over 220,000 jobs and payrolls totaling more than one and a half billion dollars a year, with an estimated three quarters of a billion dollars more added to the economy by 1973. In the area of the mining operation for services and supplies, another billion dollars a year is spent directly, along with significant local and state taxes to help finance essential public services. Local merchants benefit, too, from the coal generated payroll, for economists say that coal wages must be multiplied three times to measure the effect they have on the economy of the nation.[3]

Any way the effect of coal is measured, the impact upon the economy of coal-producing areas is impressive. When coal experiences difficulties, the rest of the economy is in trouble.

As a nation we have, generally speaking,

taken for granted our seemingly inexhaustible supply of energy. We are aware that our civilization and economy are vastly different from those of earlier times. A particular characteristic is the great amount of energy used by our people throughout their lives.

Energy is defined as the ability to do work, and power is the rate of doing work. It has been estimated that a full-grown man is capable of an average power output of about 1/20th of a horsepower during an eight-hour working day, or equivalent to an output of about 37 watts of electrical energy. Therefore, when a child turns on a 150-watt television receiver, he commands the electrical energy output of four grown men. From this we can see we would be a backward nation if we had to depend mostly on the energy of human muscles. For centuries the meager output of human and beast muscle energy was supplemented only by that which could be tapped from moving winds and waters. So long as human progress depended upon this source of energy, there could not be much advancement from primitive life. Our present economy and way of life cannot continue without the use of vast amounts of energy.

In the period 1940-68, the total power, all engines, turbines and work animals, has increased from 2.7 billion to 17.9 billion horsepower. During this same period, electrically generated power increased from 53 million to 371 million horsepower. The Federal Power Commission expects that by 1990, just nineteen years away, the nation's electrical industry will have to bring into operation nearly 900 million kilowatts of new electrical generating capacity, almost three times that which was available in 1970.[4]

By the year 2000, the Department of the Interior estimates that whereas coal provided more than half of the resources used to generate electricity in 1968, it will only contribute about 30 per cent of the total. Nuclear power as a resource for the generation of electricity, by the same estimate, will increase from less than one per cent in 1968 to the dominant position of 52.5 per cent in the year 2000.[5]

Then, too, it is estimated, if projections are correct, that by the year 2000 demands on coal resources for generation of electricity will increase from about 300 million tons per year at present to about one billion tons. "It should first of all be noted as regards these materials that there is no near-term U. S. shortage of resources in nature. Coal is, so to speak, along with atomic power, our probable ace in the hole for the next several centuries. . . . If by the year 2000, U. S. production possibly should be increased to two billion tons per year, with half of that total supplying the one billion ton demand projected for generation of electricity, coal resources in the ground appear to be fully adequate for many decades. In other words, coal is going to be mined for the foreseeable future."[6] The bottleneck will not be the availability of supply.

Coal mining, with its attractive wages and other benefits, must become a good career choice in every way. Notwithstanding the nation's need for coal, the cold day-to-day statistical record of injuries, death, and disease is reason enough for positive action. Our mine operations must provide a safe and healthful working environment. They obviously must make a profit. They must operate in such a manner that national goals of conservation and ecology are served.

More research is being done at this time in behalf of our industry than ever was done before. The full use of this supply of energy and its contribution to the well-being of America depends in large measure upon research. It is to the scientist and the engineer that coal looks for its greatest use in the future.

Efforts of the industry and government in the past have been of a corrective rather than preventive nature. In fact, one characteristic of coal mining has been that as problems develop, efforts were made to correct them. This is, of course, useful, but it leaves much to be desired because such attitudes are intolerable in this day and age.

To adequately man our mines requires a high level of competency. The industry's success and its ability to serve the nation's needs depend upon how it attracts and retains miners and technical school graduates. If it is to attract the caliber of men needed, the industry's public image will have to be greatly improved. This can be most effectively done by improving the safety performance.

Industrywide, the safety performance can be dramatically improved. Catastrophes in the coal mines are not inevitable. They can and they must be prevented. Our industry desires to see mine disasters eliminated, mine accidents greatly reduced, and mine work performed without its being injurious to anyone's health.

There are frantic efforts to make up for lost time; however, prudent men need to see that the research performed for our industry is relevant. All of the projects are interesting. Many will be useful if for no other reason than to show that some things aren't feasible. But we in industry don't want to have the wheel reinvented or even a lot of wheel spinning. We want to know things which will help us to improve safety and health in our mines.

The Bureau of Mines has for many years known and worked on problems they knew to be beneficial; many of these things have not been put to widespread use. Now that the Bureau is adequately funded for research work, everybody is getting into the act. Diverse groups working on many different projects are all right, but let's first concentrate on the things that need the most attention.

The foundation of a good mine safety program is composed of roof control, ventilation and dust control, rock dusting, and underground equipment.

Coal mining, particularly underground, has work conditions that do not exist elsewhere. We in the industry know this, and the problems caused by those conditions can be solved quicker with this knowledge. Expertise is available in the industry, in the Bureau of Mines, the universities, and labor, and I would counsel those seeking Bureau contracts to avail themselves of this talent if they truly desire to be of assistance.

Since coal has been mined for hundreds of years, the problems of coal mining are old, but many coal mine operations have achieved remarkable records in overcoming these problems. The accidents we hear most about have been explosions and mine fires, for these capture the attention, but the ones from earliest history that have taken the greatest toll are, of course, falls of roof, face, and ribs. Our concern for ventilation, methane accumulation, dust control, and safe equipment is very great, but falls of roof, face and ribs remain the beast that must be tamed. It is in this area that the quickest and most dramatic improvement can be made.

Following are suggestions for research projects which are relevant to the needs of industry.

Roof Control

The problems of roof control are ever present and they have not been solved. Some of the best ways of minimizing roof problems can be effected before mining begins. That is the first line of attack—to take advantage of the mine structure itself. Such basic things as consideration of the entry width and the pillars so as to utilize these structural components, not the antiquated idea that when we take the coal out we'll put something in its place to support the roof. This can only be done to a limited extent, and as mines become deeper, this is even more so. There is much that remains to be done if we are to eliminate this killer. It is thought our roof bolter operators would be greatly aided if a device could be developed to determine torque as roof bolts are being tightened.

One would think that with the many thousands of roof bolts installed each day, adequate knowledge for roof control has already been gained. Unfortunately, this is not true, as variable anchorage conditions existing throughout the coal mines make roof bolting research imperative.

Where coal height permits, it seems illogical not to have cabs or canopies for the added protection of equipment operators. Some older coal miners oppose this suggestion, so a general education program, as well as development work, is required to receive maximum benefit from such a program.

Ventilation

Without ventilation all underground work will cease, and in line with this, research to expedite the delivery of air to the desired area is needed. For example, a replacement for polyurethane foam which would be fire-resistant, non-toxic, easy to apply, yieldable but strong, and also a means to fireproof existing applications. Such a mate-

rial would have immediate applications for short-lived stoppings.

Difficulties are being experienced in complying with the mandatory requirements for face ventilation, especially while equipment is in the face. Probably the most difficult is adequate face ventilation for modern continuous mining machines. There is need, therefore, for much work to develop the means whereby the face can be properly ventilated to prevent ignitions and control respirable dust without adversely affecting production.

The need for more ventilation shafts can be foreseen, and this will become more acute. For this reason, techniques need to be researched and developed which will expedite the drilling and completion of large diameter (12-15 feet) air shafts. It is understood that some drilling techniques have been developed but are not available for the private sector.

As mines become deeper, in all likelihood more methane will be liberated, which will require more ventilating air to the point of liberation so as to prevent it from becoming explosive. However, more air means a higher velocity which, in turn, will suspend a higher concentration of dust particles and increase the danger of explosion and the hazard of respiratory disease. If we follow this route, we will soon be going around in circles. The most obvious solution seems to be to minimize the amount of methane entering the mine by removing it from the coal ahead of mining. The answer to this problem will require much experimentation and observation to learn what controls methane occurrence in coal and the strata, as well as its migration during mining. The Bureau has done considerable work on this particular obstacle, and it seems to be solvable.

The question of the best way to properly maintain and control pillared or abandoned areas under a variety of conditions is unsolved in industry. It is likely that a single method will not suit all conditions, and the effectiveness of bleeders needs to be researched along with the question of whether it is preferable to seal or ventilate these areas in question. Experience in mining U. S. coalbeds has been generally limited to the shallower depths. It is likely that at greater depths these problems will be more acute. One of our responsibilities is to try and anticipate the problems which will develop as deeper coalbeds are mined.

Trolley Systems

There is need for the development of better means of protection for trolley systems which require high operating currents. The varying nature of mining electrical loading is such that non-dangerous short-term peaks of current exist above the rated load values. For this reason, a device is essential to distinguish between high operating load and a short circuit.

Remote Control of Equipment

Work is being done to develop new equipment that can be remotely controlled, but this should be applicable to existing equipment. I have often thought how nice this would be on pillar work.

On-Site Permanent Splices

There is need for the development of a means other than the use of open flame to make on-site permanent splices in trailing cables in the optimum manner, and the development of a permissible quick-coupling type of electrical connector for trailing cables. The U. S. Bureau has for some time recognized the overwhelming need for on-site splices, and it is to their credit that a means for making splices as described is almost ready for the industry.

Methane Monitors

There is need for research and development to improve the reliability and serviceability of methane monitoring devices, and to reduce the cost of such devices. At this time monitors have not been found to be reliable on d.c. voltage.

Relationship of Rock Dust and Water

It is thought that research is needed to carry out the expressed intent of Congress with respect to proper relationship of rock dust and water where mobile equipment is used between the working face and section loading points. Page 22, Report No. 91-563, House of Representatives, gives three exceptions to the general rock-dusting requirement. Earlier work in the U. S. Bureau of Mines Experimental Coal Mine has shown that the explosion hazard of coal dust on shuttle car roadways can be controlled by proper application of water, dry rock dust, a saturated solution of ammonium phosphate or mixtures of water or the water-phosphate solution with rock dust.[7]

Mine Illumination

The lack of proper lighting is an inherent problem of underground mining, and the constantly moving and changing face conditions make it imperative that research be done on mine illumination to develop workable systems for machine-mounted lighting which will meet the standards and not blind men in the area. Along with this is the great need to evaluate the practical levels of illumination required for the various tasks.

Electrical Face Equipment

We are all familiar with the difficulty involved in maintaining electrical face equipment in condition to meet all the little technicalities of permissibility. Therefore, it is thought that in accordance with the definition expressed in Section 318(i) of the Act, research and development of better designs for maintenance of permissibility features are needed.

Water-Flushed Machine Bit

We have long thought how nice it would be to have a non-sparking machine bit. Research has been done on this and it has been determined that this approach just about won't work; for a tool to be hard enough to cut coal will necessitate that it be hard enough to cause a spark. About the only thing that hasn't been fully explored is the water-flushed bit, and it is hoped work will be continued on this.

Improved Flame Safety Lamp

Many of us are saddened because an important piece of safety equipment seems destined for the scrap heap. Where explosions of methane have been caused, it has not been the fault of the safety lamp because when the lamp is properly assembled and used it is versatile and honest. It would be of great help if a means could be developed for application to the permissible flame safety lamp to enable detection of 1.0 per cent methane within acceptable tolerances.

Alternate Source of Power for Underground Equipment

Increased use of electrical equipment, especially in the face areas, brings on more hazards, such as fire and ignition hazards. The shock hazard also increases with each additional cable or piece of equipment. The increase in the use of electrical face equipment indicates the need to extend research on alternate sources of power for underground equipment. We often think of Diesel power, since it is being used in some underground mining operations, but liquified gases have possibilities of being better. In connection with this, the design of the machine must be re-evaluated to ascertain changes which will permit maximum efficiency, along with minimum health and safety risks. Machines must be engineered for the human being as well as for efficient production.

Another major objective of the industry is to eliminate the health hazard associated with coal dust. In earlier days, fine coal dust was thought of as a nuisance only, and it was thought that silicosis was the only thing to fear.

Coal dust has always been a threat to the health and safety of the coal miner. The potential hazards of float coal dust are well known. When in the proper mixture of air, it is capable of producing explosions of terrifying force—events of recent times indicate that such mine disasters are still a very real threat. Research should lead to the development of methods to sample and control airborne coal dust.

A great deal of public attention has been focused upon coal dust as a health problem with many active and former coal miners suffering from the disease known as coal worker's pneumoconiosis. But regardless of the exact number, it is obvious that coal worker's pneumoconiosis is the Number One occupational health problem in U. S. coal mining. However, there is no valid reason to

assume that every miner dies of or suffers from pneumoconiosis.

The health section of Public Law 91-173 is the first national endeavor to control and eventually eliminate coal worker's pneumoconiosis from the coal industry. It attacks the disease from three directions: detection, control, and prevention. "The rate at which simple CWP may lead to PMF has not been studied in the United States, but British investigators have found that about one per cent of men with the simple form develop PMF each year, and of those with PMF, about five per cent progress." The point is that CWP prevalence should be neither minimized nor exaggerated, and that we need to reduce and suppress the respirable dust to safe limits.In view of this, research is needed to develop better means to control respirable and float dust. Along with this, much work is yet to be done in the development of sampling instruments. The present Coal Mine Dust Personal Sampler was by necessity based on the state of the art at the time the Act was passed, and it was known at the time that an improved design was needed, one which will accurately collect only the respirable dust as defined by Section 318(k).

The efficient mining and utilization of our coal reserves has become absolutely vital. With our present awareness of the hazards to man and the environment, we think these problems can be managed technologically. However, coal is not alone in this, as oil and atomic energy su fer from similar or other handicaps from an environmental standpoint, and in the economic struggle these disadvantages may balance out.

Needless to say, the coal industry has many problems, and will have many more, but the task does not appear to be hopeless. It is uniquely our job to understand the problems of this industry and to see that they are expediently solved. Throughout my coal mining experience there has been the admonition to expect the unexpected. This, I think, has been the cause of much of the fatalism prevalent in the industry, and it must be changed if we are ever to achieve the goals we seek. Our nation's exploration of space and the depths of the oceans has demonstrated that research can provide the knowledge and means necessary for men to work safely in environments much more hostile than the depths of the solid earth. This being so, then for a certainty we can find the ways to make our mines safer than has ever been thought possible.

The image of the coal industry has been tarnished too long. If an accident or an injury or a disease attributable to the industry is preventable, why not prevent it? The miner is the industry's most important resource and his safety and health are of foremost importance. Industry is willing to cooperate in safety research and to use the results of such inquiry. Many people expected a miracle from the 1969 Act. There is no miracle that this Act in itself can bring about. It can't be done by legislation. And in the final analysis, management will have to motivate their employees in safety procedures so that constructive work habits can be developed. The result will be a good safety performance and efficient production.

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GOALS AND STATUS OF BUREAU OF MINES COAL MINE HEALTH AND SAFETY RESEARCH

By JAMES J. SCOTT
Assistant Director, Mining, U. S. Bureau of Mines, Washington, D.C.

The challenge for high safety standards has been accepted by the coal industry and Federal government.The coal mine health and safety research program of the Bureau of Mines is aimed at providing the technology and the tools to improve safety in the coal mines.

Our research priorities are based largely on coal mine accident records. Underground coal mining accident rates are very high when compared to other industries. In 1969 the underground coal mining accident frequency rate was the highest among all industries—the nearly 32 disabling injuries per million manhours compared to the average for all industries of only about eight per million manhours.

We know that fatalities in coal mines have decreased significantly over the past 35 years, from over 1,200 in 1935 to 255 in 1970, and that today's fatalities occur predominantly in underground operations. However, during this period the coal mining labor force has decreased from 440,000 to 140,000. This apparent correlation between fatalities and the size of the labor force is significant. It seems to support the argument that the reduction of fatalities in coal mines has been the result of a decreasing labor force rather than any overall improvement in safety. While improvements have indeed been made in some areas of the coal mining operation, new hazardous conditions have also been created as a result of changes in other areas of the operation.

Accident characteristics in coal mines are also much the same today as they were 30 to 35 years ago. While the labor force to fatality ratio has improved only slightly over the period, the distribution pattern of fatalities in terms of the causes of the accidents has not changed appreciably either. Similarly, the non-fatal injury patterns and characteristics are much the same today as they were 30 years ago. While significant improvements in production technology have been made, social costs in terms of the health and safety of the miners have not received comparable attention. As a result, we are badly in need of new innovations and technologies to improve safety in the mines.

Historically, hazards associated with ground control problems in the form of falls of roof, ribs, and faces have been the number one killer in underground coal mines. The figure has fluctuated from 40 to 60 per cent of the total underground fatalities each year.

The adoption of roof bolting in the late 1940's has made a significant contribution towards the control of roof falls. On the other hand, the introduction of the continuous miner in the same decade, while increasing productivity significantly, has created new ground support problems near the face. Because the continuous miner exposes new roof much faster than conventional mining methods, the difficulties of maintaining adequate roof control near the face have increased. This is reflected in our statistics that over 75 per cent of the roof fall fatalities in underground coal mines occur within 25 feet of the face.

The Bureau's ground control research program is seeking a variety of ways to tackle this problem. Rock failures are caused by excessive stresses built up in the rock mass as a result of the opening created or by hanging loose rocks that are difficult to detect. Microseismic techniques have shown considerable promise in hard rock underground excavations as a means of detecting the minute noises associated with stress buildup in rocks and thus predicting rock failures. The Bureau's program includes projects to extend the application of this technique to underground coal mining. Infrared techniques for detect-

ing hazardous conditions are also being investigated. Field trials have established the feasibility of using hand-held infrared scanners to detect the minute temperature difference between loose rock and sound, intact rock.

Research on temporary supports and protective equipment is being pursued. This includes the development of an advancing mobile shield, currently in the prototype fabrication stage; a gas inflatable safety prop; and a lightweight personnel shield. These devices are intended for use by miners working in the critical areas near the coal face before permanent supports can be installed.

While roof bolting has been an important means of roof support in underground coal mines, its advantages cannot be fully utilized until there is a better understanding of the interacting process between a roof bolt and the rocks it holds together. For example, why in some instances does a roof bolt maintain its tension in the rock almost indefinitely, while in other instances it loses this tension rapidly? The Bureau's research is aimed at determining the interrelationship between such factors as bolt tension loss, bolt anchor design, and characteristics of the roof rock. In addition, the use of resin grouted bolts is being investigated and shows considerable promise for greatly improved effectiveness.

Efforts to improve underground support systems are also being advanced through research on chemical stabilization of mine structures. This work has resulted in the development of a liquid rock bolt of glass fiber reinforced polymer. Laboratory tests show that a one-inch liquid bolt is equivalent to the strength of a standard five-eighth inch steel bolt. However, actual field tests which are planned for later this year may show the liquid bolt to be far superior to the steel bolt because of the bonding created by the solidifying liquid and the surrounding rock and the additional penetration of the liquid into the surrounding rock. Such a system would also be amenable to remote installation at a distance away from the hazardous unsupported roof. Another concept of chemical stabilization that shows considerable promise is the coating of rock surfaces with a liquid polymer to prevent rock deterioration and thus greatly reduce the chances of hazardous rock falls. The longer range concept is the penetration of rocks around an opening with polymer to a depth of several inches to create a strong, competent rock structure. The major obstacle is the nature of the shale that is associated with coal beds, which makes penetration with liquid of any kind difficult. However, if successfully developed, the impact of such a system will go far beyond a greatly improved safety condition from rock falls, not to mention its important economic benefits.

Although gas or dust explosions have not been the largest contributor to coal mine fatalities, their prevention has received the major emphasis in the Bureau's coal mine health and safety research program. This is, of course, because of the potential for a disaster of major proportions from an explosion and the tragic circumstances surrounding such a disaster. By the very nature of the accident, the historical pattern of fatality rates from underground coal mine explosions is an irregular one Underground coal mine explosions took the lives of 87 men in 1968, 78 of whom died in the Farmington, West Virginia, disaster. There were no fatalities from explosions in 1969, but in 1970 explosions caused the death of 41 miners. This pattern is also true if we go further back into our records.

In line with the basic philosophy for our overall program, research to prevent gas and dust explosions is divided between seeking preventive measures that can be put into practice within a very short time frame and long term solution that will eliminate the potential for explosion from its source. For the short-term measures, instrumentation is being developed that will allow mine inspectors to determine the combustible content of mine dust without the need of laboratory analysis. Based on encouraging field test results, a second generation prototype of this portable nuclear coal dust analyzer has been fabricated and promises to be an efficient instrument. Other preventive measures under development include sensors to detect incipient fires and means to automatically apply extinguishant. The suppression of combustible coal dust by foam is also under

investigation. Design and fabrication have been completed on a prototype foam generator that will be mounted on the continuous coal cutting machine. Promising results from simulated tests indicate that this prototype device may be placed in operation in a mine shortly. Because of its dual threat of explosion and lung disease, coal dust research is being pursued through other approaches, including better ventilation practices and new designs of coal cutter bits to generate less dust at the face.

A more basic and important effort to prevent gas explosions is to eliminate the source of these explosions. Research has been accelerated, since the passage of the Mine Safety Act, on the nature of trapped methane in the rock formations and the process by which it is released into the mine atmosphere. It has been possible to successfully drain part of the methane from coal beds before mining and thus reduce the chances of explosion. Additional research and field studies are needed before such a technique can be fully exploited and accepted by the industry.

Accidents related to haulage, electricity, and machinery combined accounted for most of the balance of underground coal mine fatalities in 1970. Research on the use of automatic and remotely controlled coal mining machines is being carried out under contract. This includes development of certain sensors, displays, and control devices necessary for complete automation. Efforts in this direction will serve the dual role of reducing machinery accidents and removing miners from the working face where most of the fatal roof fall accidents now occur.

The research efforts I have discussed are essentially along traditional approaches of dealing with individual problem areas. An important study dealing with the underground coal mining operation as a whole is also underway. Identified as Inherently Safe Mining Systems, this contract study is aimed at developing an improved total mining system capable of safer operation that is competitive in cost and performance. The system will be based largely on existing technology. Hazards will be analyzed to identify ways of protecting the miner against a hazard, either by an automatic warning of impending danger or by a new procedure that removes him from the danger area. Constraints on existing mining systems will be analyzed as a basis to develop alternate operating methods, to modify current equipment, or to introduce new safety equipment. The physical environment, operational procedures, requirements of the Mine Safety Act, union work rules, and company policy will be evaluated for their inter-relationship to provide the basis for an improved overall system.

To illustrate the significance of these factors, preliminary results from a related contract study have indicated an unusually high proportion of fatalities among workers with limited work experience at the jobs they were doing when the accidents occurred. The final phase of this three-year study calls for a one-year demonstration mining operation in a coal mine to judge the performance of the system and provide a basis for implementation.

The Bureau's research program is also concerned with the study of ergonomics as a potential means of solving related mine safety problems. Ergonomics, the study of man in relationship to his working environment, may provide answers to safety problems involving the compatibility between the miner, machines, and the underground environment.

I have not been able to cover all aspects of our research programs in this discussion. What I have discussed should give you the indication that the Bureau's research program to improve health and safety in the coal mines is a comprehensive one and deals with our problems from a variety of approaches. The Congress and the American people have given the Bureau of Mines the task of improving safety in the coal mines. This is certainly not a simple task. The health and safety problems in our coal mines have been with us for decades and cannot be solved overnight. However, with the help of the academic and industrial communities and the coal industry, we are confident that many of the urgent problems can be overcome within a relatively short time frame and, in the long run, we can develop new and improved mining systems that will provide our coal miners with better working environment and greater safety protection.

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EDUCATION AND TRAINING—WHERE WE ARE AND WHERE WE ARE GOING

By DR. BENJAMIN L. HUNTON
Assist. Director, Education and Training, U. S. Bureau of Mines, Washington, D.C.

A report on the development of extensive programs being undertaken by the newly formed Division of Education and Training to insure the miner works safely in a healthy environment.

Separate Article

You have been told of outstanding advances in the area of health and safety. You have been—or will be—advised of dramatic milestones achieved in the lowering of time lost by reason of illness or accident, and in the reduction of fatalities. My report is not dramatic. It cannot be, for in the past calendar year the mineral extraction industries continued to sustain both lost time accidents and fatalities.

Hence, the need to insure that workers can perform their jobs safely, and in the case of accident, have an opportunity for survival, continues. The Bureau of Mines has embraced the concept that one way to improve health and safety in the mines is through education and training. About $6.8 million, or about 13 per cent of the Bureau's health and safety funds, are currently being spent for this purpose. Included are the statistical work being done to provide information on accidents and injuries, as well as the courses being developed and conducted to train mine workers, including supervisors, in first aid and good health and safety practices. The goals in this part of our program can be stated very simply: To point out the hazards in the mines, and to train and to motivate the workers to avoid them. A key word here is, "motivate." It is not enough for a worker to know how to be safe; he must be motivated to be safe.

Too many mine workers, including foremen, are still taking risks they know they should not take. A recent study concluded that perhaps as many as 151 of the 255 fatalities that occurred in coal mines last year could have been avoided if a foreman who was determined to avoid unnecessary risk taking had been present. In 41 of those cases, a foreman was present; and in 13 cases, the foreman himself was killed. Of course, this conclusion is based on subjective judgment. However, someone else looking at the same fatality reports would probably come up with a different set of numbers; anyone would most likely conclude that a high proportion of the fatalities resulted from unnecessary risk taking. It seems reasonable, therefore, that such risk taking can be stopped and the injury and fatality rates can be significantly reduced.

Education and training appears to be our best hope for achieving a reduction in injuries and fatalities. Somehow, we have got to convince mine management that it must provide better health and safety supervision and discipline in the mines and, at the same time, convince the workers and their unions that they must support management actions in this regard. The safety of the workers is not a negotiable issue at the bargaining table. It is one area in which the goals and objectives of management and labor should coincide.

The historic approach of the Bureau has been to attempt training without education, to present information without regard to pedagogy. To put it more simply, we have attempted to teach without knowing how to teach. Texts were prepared, rather than courses, and were usually authorized by mining engineers, persons who, while competent

in their fields, often could not reach the academic level of the intended consumers. Instruction was attempted by mine inspectors and mining industry safety officers, men of ability and good will, but already carrying a heavy burden. And generally, the mine operator was left without an obligation in this area. One may justifiably assert that the period prior to 1969 was the "horse and buggy" era of education and training in the Bureau.

A reorganization of the Bureau of Mines provided, among other things, for the staffing of a separate entity for education and training. Within a year, it had become apparent that efforts for behavioral change in all miners, from the foreman to the specialist, and attempts to employ education as a tool for health and safety would have to be divorced from the enforcement function. Accordingly, the decision was made to place the conduct of instruction within the mandate of the education and training organization.

Plans were swiftly made to create a Divison of Education and Training Operations that would furnish direction for ten training centers spread across the country. A center would be a base of operations for persons conducting training at mine sites, it would be a resource center for local industry, and it would provide—in its training room—an adequate space for conferences, seminars, classes, and similar programs involving Federal, state, and industry representatives.

These centers will each have from 12 to 30 professional employees. Each is, or will be, headed by an experienced Bureau employee. But the subordinates are to be recruited primarily from outside of the Federal government. This design is deliberate; we will not become an inbred organization. Moreover, our immediate superior, the Deputy Director of Health and Safety, has imposed the requirement that hiring be equalized between training and education specialists.

We are rapidly expanding our instructional force from less than 50 last June to more than 200 next June. As an equal opportunity employer, all major racial and ethnic groups can quickly be identified in the Bureau's training and management ranks. What is more, we have two women in the boondocks conducting training programs and two more undergoing indoctrination. The tempo of concern is so great that time and time again female administrative and clerical employees demand the opportunity to go underground.

The existing training centers or those being activated are located in Albany, New York; Albany, Oregon; Barbourville, Kentucky; Beckley, West Virginia; Bristol, Virginia; Chicago, Illinois; Dallas, Texas; Denver, Colorado; Pittsburgh, Pennsylvania; and Reno, Nevada.

Furnishing back-up for these centers is our Division of Education and Training Services, a reorganized and revitalized version of an earlier organization. The function of this unit collocated with other Bureau operations in Pittsburgh, Pennsylvania, is to design training materials, to field test them, and to distribute them for use by our trainers and cooperating teachers from industry. Courses of instruction comprise the bulk of this production. Generally, a course is designed for classroom presentation and will include an instructor's guide as well as study material for the student. To reinforce this approach we are rapidly developing correspondence courses and programmed materials.

Maximum use is made of audio-visual materials, including motion pictures. Last year 1,597,512 persons viewed 62 Bureau films, and one of our films, entitled "Protection Against Radioactivity in Uranium Mines," won First Place in the Gold Camera Award of the U. S. Industrial Film Festival; this year, another film, entitled "Prevention of Pneumoconiosis thru Engineering Controls," has been awarded an Honorable Mention in the 13th Annual Industrial Photography Contest.

One of our exciting involvements is the development of the U.S. Mine Health and Safety Academy. The parameters of this institution have been firmed; the curriculum is in the test stage; the site has been acquired in Raleigh County, W. Va.; and the architect is concluding the design. Faculty and staff selection has begun, and 47 trainees are presently undergoing instruction in a leased, inadequate facility in Beckley, W. Va. This Academy will train Federal mine inspectors and training specialists in courses of up to eighteen months duration, and persons from

industry and schools of mineral technology in seminars and short courses. Hopefully, state employees—inspectors, technicians, trainers, and managers—will enroll in these unique programs. This Academy will be the only institution of its kind in the United States, and perhaps the world.

Training of miners in job skills is another area into which we are venturing. For some of this, although we lack a legislative mandate, we substitute a sense of moral obligation. The all-too-prevalent practice of on-the-job training, the Buddy System, simply does not work. In mining, as in many other fields, OJT means you learn not how it should be done, but how your mentor does it. The inevitable result is the transmission of bad habits from one work generation to another.

An appreciation of the need for skills training may be gained from those figures regarding the number of new employees that will be needed for underground bituminous mines alone: 12,500 in 1971 and 1972, 13,000 in 1973, 12,550 in 1974, and 12,850 in 1975. To face this demand, we have created a Cooperative Training Office.

At this moment, the Bureau sponsors a Mining Technology Program whose purpose is to provide training for 175 unemployed, entry-level workers and to upgrade training for at least 200 present employees in both coal and metal mines. This is a pilot program designed to test a new curriculum concept built around a basic core of fundamental mine technology. It features learning how to do the job with marked emphasis on health and safety. The program is being implemented at the following locations: in Butte, Montana (Entry-Level and Upgrading); in Price, Utah (Entry-Level and Upgrading); in Leadville, Colorado (Entry-Level); and in Richlands (Upgrading) and Grundy, Virginia (Entry-Level). This project is funded under the authority of The Manpower Development and Training Act of 1962, as amended, in cooperation with the Department of Labor and the Department of Health, Education, and Welfare. Funding has been made through an inter-agency agreement with HEW.

We shortly will commence another pilot project to provide training for 192 employees of 27 companies of the Central Pennsylvania Coal Producers' Association. This program will demonstrate how the operation of mine machinery can be taught with particular emphasis upon safety. The project will use a simulated mine above ground and related production activity underground to provide a realistic method of manpower development. The project will also provide a training design that can be used throughout the industry.

The above-ground training will be handled by the Pennsylvania State University, Department of Mineral Engineering, while the below-ground activity will be coordinated by association members.

Along with the development of a meaningful training capability, we are involving management (The Coal Mine Health and Safety Act places an obligation upon management), we are expanding and improving our corps of "cooperative teachers" who are instructors on mine payrolls, and we are seeking to make the safety associations dynamic organizations.

Thus, the Bureau of Mines has direction, manpower, and momentum. Education and training is on the way!

ROLE OF THE STATE IN TRAINING— ESPECIALLY QUALIFICATION AND CERTIFICATION

By J. H. MOSGROVE
Asst. to the Commissioner, Kentucky Department of Mines and Minerals, Lexington, Ky.

The Kentucky Department of Mines and Minerals is responsible for the development of policies and procedures concerning the maintenance of health and safety standards in the mining industry of Kentucky.

The Department fully recognizes the need for improvement of health and safety standards in coal mines. However, the Department also recognizes the fact that the majority of coal mine operators in Kentucky are ill-prepared to meet the minimum health and safety standards established by the Federal Coal Mine Health and Safety Act of 1969.

The Department has assumed prior responsibility for health and safety instruction of miners in Kentucky and will assume the additional responsibilities for more extensive training so as to insure compliance with health and safety standards as delineated by the Federal Coal Mine Health and Safety Act of 1969. Grants will be used to improve and supplement existing health and safety programs carried out by this Department. Chapters 351 and 352 of the Kentucky Revised Statutes (Laws Governing the Mining of Coal and Clay) provide the agency with authority to carry out the purposes of Section 503 of the Act.

The Kentucky Department of Mines and Minerals has employees who are capable of carrying out inspection duties as required by the Act, and provisions are made to supplement the present staff with technical personnel needed for expanded programs. It is intended to supplement, not supplant, existing state coal mine health and safety programs, using funds made available by the Federal Coal Mine Health and Safety Act of 1969.

Purpose

The purpose of this project is to apply for funding to enable the Department of Mines and Minerals to expand its existing programs of coal mine health and safety; to develop new programs for the training and education of coal miners, operators, and agents in coal mine health, safety and rescue; and to acquire the additional staff and equipment necessary for the implementation of this program.

Rationale

In 1969 1,697 coal mines were licensed in Kentucky. The Department of Mines and Minerals has divided the coal mining regions of the state into five inspection districts. These five districts facilitate services for mine inspection, mine educational instruction, and training. A mine rescue station which serves as the district office is centrally located in each district. The exemplary service performed by the staff of these districts can be illustrated by the 1969 record of 3,273 tons of coal produced per fatality. This record was the best in the nearly one-hundred year history of the Department of Mines and Minerals.

Kentucky's coal mining regions provide direct employment for approximately 20,000 miners and operators. Seventy-five per cent of these miners are employed by small, independent mines which lack the organization and financial means to provide the technical knowledge required in meeting the standards of the Federal Coal Mine Health and Safety Act.

Plan of Work

The Department plan calls for the full

implementation of its various programs within a twelve-month period. A three-phase work plan outline has been developed. Phase 1 covers the first 60 days of the grant period. In this phase we will initiate screening and selection of additional staff, acquire additional staff, initiate development of full work plan and reporting systems, and initiate processes of acquiring additional equipment. In Phase II, the second 120 days of the grant period, we will complete the work plan, review existing programs and activities, begin the development of new programs, implement the work plan, and acquire additional equipment. Phase III covers the final 180 days of the grant period and continues indefinitely the implementation of revised programs, implementation of new programs, and evaluation, revision, and up-dating of all on-going programs.

Training Program

Testing and Protective Devices

Training in the use of flame safety lamps, methane detectors, and protective devices such as dust respirators will be conducted in regularly scheduled courses held in schools or other strategic locations near the center of need. Classroom work will be by demonstration, participation, and by field follow-up.

Training in the above will be provided as needed by the industry. This will be determined by request and by promotion by safety instructors of the Department where it is obvious that the training would satisfy safety needs.

The length of time of the training in the use of equipment will be governed by each instrument or apparatus for the time it takes to thoroughly familiarize the employee with its use. Equipment will be furnished by the Kentucky Department of Mines and Minerals.

Airborne Dust Sampling

Training courses in airborne dust sampling techniques may be incorporated in the program, and if so they will be conducted at strategic locations throughout the coal fields in areas where requested or where there is an obvious need as determined by the Department of Mines and Minerals.

The content will be in the use of personal and MRE sampling units. This training will be accomplished by demonstration, preparation, and the use of instruments. On-the-job follow-up will be provided by the instructors. Instruments owned by the Department of Mines and Minerals will be used by participants in classroom and field work.

It is expected that at least 15 hours will be required for this work. Any person employed in the coal industry will be permitted to take the course, with a minimum of 12 persons per class. Evaluation will be made based on the individual's performance, classroom participation, and by follow-up by the instructors.

First-Aid Practices

First-aid training will be provided by the Department at locations near mine operations which provide the shortest travel distance for the employees. When sufficient people are available, classes will be held at the mining property. The need for training will be determined by request from operators and where it is evident to the Department that the training should be conducted. The latter will have to be achieved by promotion.

First-aid teams will be encouraged to compete with teams from other localities in contests held by local safety groups and the Kentucky Department of Mines and Minerals.

Mine Rescue Procedures

The Department of Mines and Minerals will provide mine rescue training at mine sites. Teams trained in mine rescue procedures are normally more often needed at larger deep underground mines, although training will not be restricted to these areas. Training will be provided upon request by the coal operator or representatives of the employees and also by the Department of Mines and Minerals. The training will consist of instructions in the functioning and use of self-contained breathing apparatus and all-service gas masks.

Men will be training to serve on six-man teams coordinated to work together in the event of a mine disaster. These teams also

will be encouraged to compete with teams from other mines or localities in contests held by local safety groups and the Kentucky Department of Mines and Minerals. Persons selected to participate in mine rescue training will be limited to men under 50 years of age who are strong physically and who are able to participate in recovery work following mine disasters.

Elements of Practical Coal Mining

A course in Elements of Practical Coal Mining will be conducted at mine locations or in strategic areas serving groups of mines. The need for these courses will be determined by requests from coal operators or mine employees. If the Department determines a need for this type of training where no requests are made, the course will be promoted by the Department.

Courses in Elements of Practical Coal Mining will consist of the following subjects: Mine Gases, Mine Ventilation, Mine Fires and Explosions, Explosives and Blasting, Electricity as Applied to Mining, Roof Control, and General Safety Practices. Technical instruments required for mine safety work such as flame safety lamps, gas testing devices, air measuring devices, and protective equipment will also be taught as a part of the course.

This course is strictly classroom type instruction using text books, practice materials, instruments, apparatus, and visual aids. Participants will be trained in each section and tested before the next section is begun. Persons who have finished this training should be able to qualify as coal mine supervisors, safety committeemen, mine inspectors, etc.

The customary time for this course will run from 60 to 80 hours in two-hour evening sessions. The duration of the course will be dependent upon the ability of the participants to progress.

Persons permitted to take this course will be coal mine employees, supervisors, or others related to the coal mining industry interested in the subjects.

While the training courses just mentioned do not cover all the specified requirements in detail, they usually cover the training necessary for "certification" and "qualification" as required by the Act. Our Department is trying diligently to tailor programs to provide certification and qualification where necessary and will issue certificates as necessary. This will require some coordination with the Bureau of Mines in defining and spelling out these areas.

Inspection District Organization

The Kentucky Department of Mines and Minerals is currently operating with five inspection districts, four of which are in eastern Kentucky and one in western Kentucky. Each district is under the supervision of a district supervisor who also is in charge of the mine rescue station in that district. When fully staffed, each district has an average of five mine inspectors, including a supervisor. Practically all small mines are in the eastern Kentucky area, although there are also several large operations in the region. The western Kentucky district is made up of large underground and surface mining operations, with several other large mines beginning operations or proposed in that area.

At this time the Department has five training and education instructors employed under this program. In the past, mine safety instruction has been done by mine inspectors along with their other duties. It is proposed that a full time mine instructor be appointed for each district. Two electrical instructors, one in eastern Kentucky and one in western Kentucky, would be stationed at strategic locations to best serve the needs of the area. One industrial hygienist with two technicians would be attached to the central office in Lexington, and the airborne dust sampling control program would work in conjunction with our present inspectors for technical underground advice. This would add 10 persons to our present staff.

Under this proposal, we hope to further modernize our mine rescue stations which may also be used as bases for mine rescue training operations. Safety instructors assigned to the district would be placed in charge of the mine rescue station along with teaching activities.

Equipment

It is proposed that new two-hour oxygen

breathing apparatus be obtained for training purposes and for actual use if necessary. This equipment will become a part of the district mine rescue station under the supervision of one of the safety instructors. With the equipment already on hand and the addition of the new rescue apparatus and other equipment set forth in this proposal, our rescue stations will be upgraded to excellent standards. Modern mine rescue stations, plus the expertise of our inspection department with many years experience in rescue and recovery operations, will provide an excellent program for both training and emergency work. A proposed purchase of five mine rescue communication sets will further modernize the mine rescue units and expedite rescue operations in event of a mine disaster. To add to the above, five proposed fire fighting units, one posted at each station, will provide early control of coal mine fires. The proposal for first aid training kits will supplement material already on hand and will expedite training of mine personnel in first aid practices.

Projectors, cameras, screens, etc., will be purchased because they are a necessary part of any effective training program.

In conclusion, while we have had some success in recruiting qualified men to work under our training program, some difficulty has been experienced. We have been rather exacting in our standards for new personnel, and the price we can pay is still not consistent with industry and the Bureau of Mines. While we take a dim view of lowering employment standards we may be forced to do so to compete. This will be the very last resort.

To be perfectly frank, the labor market for the type of person we want seems to be in a state of indecision. It appears that some good prospects are not sure of which direction to move and question the future of any job with any company or agency. Maybe they have a right, under present day circumstances, to feel the way they do. It is our combined responsibility to bring about order so that good men will have at least a reasonable assurance of the future.

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DUST SUPPRESSION—UNDERGROUND MINES

By ARTHUR HAWTHORNE
Safety Eng., Hanna Coal Co., Cadiz, Ohio

The author questions the standard set for dust concentration and also reports on some new equipment for effectively lowering dust levels.

There have been many remarks made, both public and private, concerning the effectiveness of the 1969 Coal Mine Health and Safety Act. Most have not been complimentary to either the coal operators or the United States Bureau of Mines. It's time we all realized that the respirable dust section of this law has been extremely successful in its basic intent of reducing the level of dust concentration in underground coal mines. This is true for most of the larger responsible mines in this country.

Several hundred personal dust samples taken of the "high risk" men at two of the underground mines at Hanna Coal Company beginning in mid-1969 show an improvement which has been quite remarkable in this two year period; however, the average concentration has been fairly well stabilized during the past few months.

There were no exotic means used to accomplish this lower level of dust concentration—just a lot of hard work and adherence to basic principles already proven. With our

exhaust fan ventilating system, we increased tubing size (20 inch diameter) so that some 5,000 to 8,000 cfm sweep the face (depending on the length and condition of the tubing).

We maintain the tubing as near as possible to the face. A larger number of better located more efficient water sprays necessitated larger water supply lines to the miners (16 to 22 gpm per miner). A cleaner intake air resulted from better attention to roadways and transfer points; at the same time better rock dusting procedures were instigated.

We feel, in all honesty, that the level of dust concentration for the last few months (2.2mg/m_3 average) is just about the minimum average we can hope to consistently maintain under presently available technology and very careful operating practices. This just simply means that under the proposed two mg. standard to become effective in December 1972 most continuous miner sections will be out of compliance about half the time.

What can or should be done about this situation? The most obvious and most realistic approach would be to extend the three mg. standard for at least another year. This could be justified on the basis of the diligent cooperative approach by both the Bureau of Mines and the responsible operators, resulting in the dramatic reduction in dust. We're not alone: other mines have shown similar progress and limitation.

Let's go a step further and examine the latest Bureau of Mines figures on this country's estimated 4,500 operating sections. They report that some 80 per cent have now completed at least one sample cycle—we should be able to assume that the other 20 per cent just have not yet been able to get their dust level low enough. At any rate, about 60 per cent of the total estimated sections are at or below three mg., and 40 per cent of the total are at or below two mg. In other words, based on these statistics, under a two mg. standard 60 per cent of this nation's operating sections would be out of compliance.

Many responsible people in the Bureau are fully aware of the limitation of present technology as well as the inadequate instrumentation and sampling procedures: it's time full use was made of available facts and knowledgeable advice.

The next and most important justification for the extension would be a consideration of the fact that there just has not been any medical history published that would indicate that even the three mg. exposure causes lung damage. It was quite apparent that during the inception of the 1969 law our people leaned quite heavily on the British for evidence in establishing dust limits. These people have researched this problem for over thirty years, and as a result of this work have established a limit of 8 mg/m_3 at the face, or 4.3 mg/m^3 where adjusted to the portal to portal basis (similar to what we are using). At the symposium on respirable coal mine dust in Washington, D.C. in 1969, W. H. Walton, of the Institute of Occupational Medicine, National Coal Board, presented a very comprehensive paper. I would like to quote his answer to the question: What is your standard for the probability of contracting pneumoconiosis based on? He said, "The results of the pneumoconiosis field research over ten years were projected to give estimates of the probabilities of men contracting category 1 or category 2 pneumoconiosis after 35 years exposure to various concentrations of colliery mean coal face dust. At a colliery mean concentration of 4.3 mg/m_3 (portal to portal), the probability of contracting category 2 or more in 35 years is, I believe, a little over three per cent. But I must remind you that many men will not work on the coal face as long as this, and that any developing cases of pneumoconiosis should be detected by periodic x-ray examinations before category 2 is reached."

In the very next paper presented, H. N. Doyle of the United States Bureau of Mines said: "Based on the best available epidemiologic evidence, the public health service in December 1968 recommended the value of three mg/m_3 of respirable coal mine dust as a hygienic standard." There seems to be considerable discrepancy here, especially when considering the proposed two mg standard.

Let us consider the sampling program itself—primarily with instrumentation and sampling procedures and the resulting inaccuracies which force us to average a little over two mg. in order to have any consistency

in maintaining the present three mg. standard. Shortly after the start of the official sample cycles, we decided we could not conduct an effective program by waiting the many days required to receive the sample results from the United States Bureau of Mines. Therefore, we set up and are still continuing the policy of taking dual or twin samples on the high risk man—one for the Bureau, and one for us to weigh. The results of a study to evaluate the accuracy of the sampling program using two side by side personal samplers within a few inches of each other during the same operating shift, show many samples are fairly close, although there is a wide variation in some. By averaging all of the high weights against all of the low weights, we find that the actual instrumentation accuracy is a plus or minus 14 per cent from the overall average, or a total variation of 28 per cent based on more than 80 total samples.

This overall average inaccuracy is bad enough in itself. More disturbing is the extreme variation in several of these dual samples. For example, in two cases one sample weighed 1.2 mg. and its twin sample weighed 4.8 mg. This would certainly indicate a need for a computer record system which would make allowance for at least one bad sample out of ten due to sampling procedure, weighing, clerical error, or deliberate tampering with the cassette during the sampling shift. Another illustration of this need is a notice of non-compliance (one of three similar ones received by us the same week) in which the general trend of weights average some 1.3 mg.; then comes the one extreme weight of 41.0 mg., which naturally throws the whole series out by itself. I might add that, at our request, the Bureau of Mines did find these three cases to be decimal place errors in the initial factory weights of these cassettes.

Another phase of our sample accuracy evaluation program was to spot-check the United States Bureau of Mines' weights against our weights. At random, we weighed samples, resealed them, and sent them to Pittsburgh for their analysis. The average weight of 40 samples by the Bureau of Mines was 2.19 mg.; the average weight by Hanna was 2.07 mg. The 0.12 mg. or 5.8 per cent difference doesn't seem to be very significant when we look back at the total spread of 28 per cent experienced with simultaneous side by side sampling. However, it is again rather disturbing to note that nearly 25 per cent of these cassettes had more than a one milligram difference between our weight and the Bureau's.

Another set of statistics should be examined at this time: Ten exposed cassettes were weighed, resealed, stored for a few days, and weighed again. This procedure was repeated again, so that we had three weights on each cassette spread over some four weeks total time. The average initial weight of all ten was 2.87 mg., the second weighing averaged 2.70 mg., and the third weighing also averaged 2.70 mg. We can only assume that the 5.9 per cent weight loss from the original was due to a moisture reduction in the cassette. However, here again this variation is certainly not significant when compared to the 28 per cent variation seen in the basic sampling procedure itself.

The purpose of these figures is to partially justify a few realistic changes suggested in the present system:

1. Extend the three mg. standard for at least another year.
2. Permit each operator, if he so desires, to weigh all samples himself. The United States Bureau of Mines could then accept the operator's weights, reweigh all samples, or merely spot-check the operator's weights.
3. Throw out the highest and the lowest weight in each ten sample cycle, to provide a more honest statistical evaluation.
4. Press harder for a simpler and more accurate means of measuring dust concentrations.

Much work has been and is being done in furthering the technology of dust abatement with various measures of success. Too much of this work, however, has been repititious, overlapping, or inconclusive, simply because of a lack of guidance, finances, or adequate mine test facilities where the research work comes first and production is of relative unimportance. I think it is time we got organized in some manner so that the available time, money, and effort is utilized for the most productive results in the most needed areas of improvement involving both health and safety.

Work has been done in the following areas: water infusion of coal seams; wetting agents in spray water; compressed air-water sprays; cutting bit design; variation in cutting speeds; use of foam as a dust deterrent (we are presently cooperating with the Deter Company on a foam project under research grant to them from the United States Bureau of Mines). The use of miniature air cleaners to supply breathing air only to the operator has been explored (a cryogenic air supply has also been worked on). These devices do work; however, they are really only highly refined respirators, since the man must wear a face piece and only he gets the benefit. Other divisions of Consol, as well as other parties, have successfully worked on simplified scrubbers for the discharges of the ventilating exhaust fans. This doesn't help the operator, although any reduction in the total float dust being dumped into the return airways is certainly a most important step in the right direction from a mine safety standpoint.

Many people are of the opinion that, after everything possible has been done to minimize the actual generation of dust, the most logical and potentially beneficial direction to go is to have a scrubbing device mounted on the continuous miner which will remove a maximum amount of the air-borne dust before it is dispersed, then to get it out of the mine; this would not only reduce the exposure concentration of the men at the face but would also eliminate much of the potentially dangerous float dust in the entire mine. The first problem here was to locate an effective device small enough to stay within the physical limits of the available mine dimensions. Hanna has cooperated since 1968 with T. J. Gundlach Machine Company of Bellevile, Illinois, in adapting their miniature scrubber to a continuous mining machine. In brief, their device consists of a hydraulically driven rotor which internally performs the three basic functions required—it moves the air, it internally mixes the water and the dust, and it can also internally separate the dirty slurry from the cleaned air. In April, 1970, after extensive development work, a successful prototype was mounted on a Lee-Norse 45-E Miner at Hanna's Rose Valley Mine. Our own extensive evaluation of this principle showed excellent promise, reducing the respirable dust level of the operator by about 50 per cent and at the same time reducing the total dust load going into the return airways from our ten horsepower ventiliating exhaust fan by a like amount.

At our request, the Pittsburgh Field Health Group of the United States Bureau of Mines sent a team of four men to the mine to conduct a performance study of this unit. Their report was quite complimentary to the ability of this prototype unit to reduce both the respirable and the total float dust. In operation, this unit pulled the dusty air from just behind the cutter drum and dumped the clean air over each side of the machine, at the same time the black slurry was deposited on the coal conveyor.

It was realized that this unit was still too bulky for most applications (although most of the bulk was in the pick-up and discharge ductwork) and Gundlach proceeded to develop a more miniaturized version. The resulting design involved a rotor four inches high by 18 inches in diameter. We have no proven test figures as yet; however, I have heard some encouraging results from other mines now participating in this work. Probably the most optimistic results to date on these "mini-scrubbers" comes from a factory installation on a new National Mine Service Drum Miner. This machine was tested in southern Illinois, and the figures gathered by a team of Federal inspectors indicated a week's average dust concentration of 1.8 mg. with the scrubbers operating, as compared to 2.74 without the scrubbers.

Others, including B.C.R., Jeffrey, Joy, Donaldson, and several other operators have done work in this same general direction; however, there has been very little correlation of ideas and progress.

It's my opinion that enough evidence has been shown as to the potential benefits of this general basic approach to mine dust control to justify a full scale research project. This really should be carried out under the guidance of competent men from manufacturers, union, operators, and government—it's about time we indulged in more cooperative efforts in all areas of mine health and safety.

In this case, as in most others, effective practical application of laboratory proven developments ends up being, by far, the most difficult phase of any project. Perhaps one answer to this would be the establishment of a full scale continuous miner section devoted completely to research work.

Again, the United States Bureau of Mines, the union members, and the responsible operators are to be complimented on the rapid progress made in this area of the law. This program should not be allowed to degenerate into a "numbers" game, but rather the limitations of present technology involving both dust abatement and measurement instrumentation should be accepted at this time with a concentrated effort made for further advancement in both areas.

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