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NATIONAL
SAFETY
COUNCIL

TRANSACTIONS

VOLS. 15-28

1967

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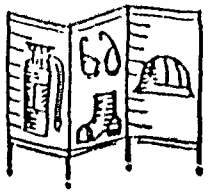

1968 1969 1970

NATIONAL SAFETY CONGRESS

OCTOBER 28-31, 1968 / CONRAD HILTON HOTEL, CHICAGO

The Congress is always a big week, a worthwhile week for the 13,000 safety people who attend.

At the '68 Congress you can meet other safety people, with the same problems and responsibilities as yourself. You can exchange views and ideas on accident prevention, health, hygiene, and fire prevention . . . on safety in industry, traffic, school, at home and on the farm.

You can see the largest of all safety equipment exhibits at the Congress . . . an opportunity for you to make well-informed buying decisions for your company.

This four-day educational program, planned and presented by the National Safety Council, can be your most thought-provoking, most worthwhile safety experience in 1968.

Make plans early to attend the 1968 Congress and bring the other people in your organization who have safety responsibilities.

FUTURE CONGRESS DATES
1968 October 28-31
1969 October 27-30
1970 October 26-29
1971 October 25-28
1972 October 23-26

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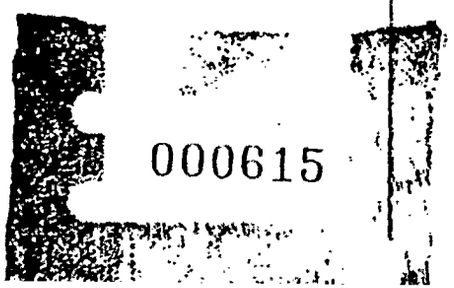

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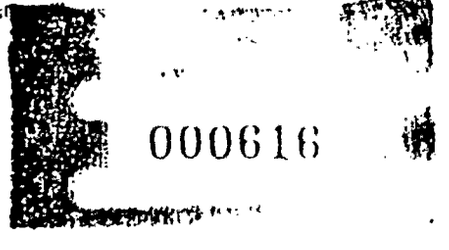

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ANNUAL COUNCIL MEETING

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By RABBI MORDECAI SIMON
Executive Director of the Chicago Board of Rabbis

Almighty and Eternal God:

Inspired by your ethical and moral teachings, we have come together to reflect upon our progress to this time and to consider the tasks still before us.

As citizens of a nation dedicated to the Fatherhood of God and the brotherhood of man, we are charged to do justly, love mercy and to walk humbly with You; to extend compassion, understanding and aid to the perplexed and sorely-tried; to love our neighbor as ourselves.

To these humanitarian heights has the National Safety Council dedicated itself through its noble aims and purposes of constantly working, studying and planning for means that will result in the extended health, welfare and education for all.

To these noble ideals, we pray, may we ever remain faithful, as we develop a continuing sense of dedicated commitment to this organization, our respective professions and those we serve, a commitment which both elevates and ennobles.

We beseech Your blessings upon all who have affiliated themselves in the attainment of these common objectives. Endow them with the knowledge, wisdom and guidance necessary for fruitful leadership and success in the attainment of these goals . . . Inspire us to labor zealously and unflinchingly for the perpetuation of the American way of life.

Guard our county from iniquitous designs, intolerance and blind prejudice. Keep our borders free from every enemy, both from within and without . . . Grant us clear minds so that we may approach the problems of our day with forthrightness and unselfishness . . . Spread Your tabernacle of peace over all the nations of the earth.

May the work of peace be righteousness, and its effect freedom from fear and want for all men. *Amen.*

Penalties

Penalties of both a civil and criminal nature are provided for in the Act.

A civil action for preventive relief, including an application for a permanent or temporary injunction, restraining order, or other order, may be instituted by the Secretary in the district court of the United States for the district in which the mine in question is located or in which the mine operator has its principal office, whenever an operator (1) violates or fails or refuses to comply with any order of withdrawal and debarment, or (2) interferes with, hinders, or delays the Secretary or his duly authorized representative, in carrying out his duties under the Act, or (3) refuses to admit an authorized representative to a mine, or (4) refuses to permit the inspection or investigation of any mine, or of an accident, injury, or occupational disease occurring in or connected with a mine, or (5) refuses to furnish any information or report requested by the Secretary.

Upon conviction, persons may be punished by a fine of not less than $100, or more than $3,000, or by imprisonment not to exceed sixty days, or both, where (1) there is a violation or failure or refusal to comply with an "Imminent Danger Withdrawal Order," or (2) there is a violation of a mandatory standard and failure or refusal to comply with an order of abatement if the failure to comply with the order of abatement has created an "imminent danger", that is, a danger that could cause death or serious physical harm in such mine immediately or before the imminence of such danger can be eliminated.

These criminal penalties have a peculiar twist to them. In Senate Report No. 1296 the Committee stated—

"Section 14(b) . . . makes mine operators liable to criminal penalties (fines of $100 to $3,000 and imprisonment for up to 60 days) upon conviction in Federal court of one specified offense. This offense is: violation of, or refusal or failure to comply with, an order of withdrawal and debarment, if, at the time the order is made, a danger exists 'that could cause death or serious physical harm in such mine immediately or before the imminence of such danger can be eliminated.'

"These criminal penalties do not apply, therefore, to a mine operator who has been given a notice fixing a time limit for abatement of a violation of a mandatory health or safety standard, who has failed to abate the violation within the time allowed, who has then been given an order of withdrawal and debarment, and who has then violated, failed, or refused to comply with this order —unless his failure to abate the violation has created an imminent or immediate danger of death or serious physical harm by the time the order of withdrawal and debarment was issued."

Thus, it would seem that an offense has been committed if between the time of issuance of a notice of abatement fixing a time limit within which to abate, and upon the expiration of the time, the failure to abate the violation of a mandatory standard has resulted in a condition of imminent or immediate danger.

The Act was effective on September 16, 1966; however the provisions with respect to issuance of "Imminent Danger Withdrawal Orders" and "Elapsed-time Withdrawal Orders and some of the penalty provisions do not become effective until one year after the date of publication of notice in the *Federal Register* of the designation of mandatory standards.

The meanings and interpretations of the Act in many respects will have to await the time when we are faced with actual situations and circumstances which undoubtedly will arise after the Act becomes fully operational. Some questions and disputes may not be entirely clarified or decided until cases are heard and decided by the Board of Review and by the courts.

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problems. Invite them, seek them, get them to come to you. Be approachable.

9. Have a trial period, followed by a careful re-examination by all people concerned.

Helpful Hints for the Successful Supervisor.

The five most important words of a supervisor are, "I am proud of you."

The four most important words of a supervisor are, "What is your opinion?"

The three most important words of a supervisor are, "If you please."

The two most successful words are, "Thank you."

The one most important word is, "Your."

The least important word is, "I."

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55th NATIONAL SAFETY CONGRESS

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IMPORTANCE OF DUST CONTROL

By HENRY N. DOYLE
Assistant Chief, Division of Federal Employee Health,
U.S. Public Health Service

One could dispose of the assigned topic in a very short order by stating that dust control serves two primary functions—disease prevention and explosion control. I would assume, however, since you have asked me to discuss this subject that you are anticipating a much more philosophic treatment and, because of my background, your interest is in the health aspect.

If we are to view this problem from the philosophic viewpoint, three factors must be considered: The biology of man, our present state of knowledge, and our social concepts.

First, let us look somewhat superficially at the anatomy of the respiratory system. Man's respiratory system evolved to handle a relatively pure mixture of oxygen, nitrogen, and the noble gases. However, to protect the lungs from the natural contamination of the atmosphere, such as wind-blown dust and pollens, several protective mechanisms developed. The nose became prominent and was filled with many small hairs to serve as a filter device for particles as small as 5 microns. The respiratory tract between the nose and the major branches of the lungs developed fine hairlike structures which served to trap the dust particles and, by means of a continuous upward motion, to reject through the nose or mouth. Finally, if a dust particle penetrates these defenses, the lung tissues were equipped with phagocyte cells which engulfed the dust particle and removed it from the sensitive area.

Thus, man is equipped to live in an environment which nature planned many eons ago. When the natural defenses of the respiratory tract are broken down, the lung finally becomes a physiological dust trap. The miracle is that man can survive in today's environment which is vastly different from the environment which nature planned. [illegible] of us who live and work in an urban [illegible] suffer a constant insult and an overload[illegible] the respiratory system due to man's [illegible]ntamination of the atmosphere. Superimposed on the technologic contamination of the atmosphere with particulate matter, man [illegible] insults his respiratory system by [illegible]g which is known to destroy the ciliary and phagocyte systems, thus increasing the risk resulting from exposure to industrial dust and atmospheric pollution.

Those of us entering the 5th and 6th decades of life represent the first generation to be exposed to a continuous complex technologic contamination of the general atmosphere, coupled with the almost universal practice of smoking. Thus, it should be no shock to realize that respiratory diseases are assuming a more prominent place in the nation's morbidity and mortality pattern. Chronic bronchitis, emphysema, most forms of lung cancer, and certain forms of congestive heart disease all result from the deposition of particulate matter in the lungs. For those exposed to industrial dust, the hazard is intensified and extended to other diseases such as pneumoconiosis and heavy metal poisoning.

Although epidemiologic evidence is lacking, observations tend to support the conclusion that respiratory diseases other than the classical occupational ones are more frequent among workers exposed to industrial dust. That massive dust concentrations over a prolonged period destroy the natural defenses of the respiratory system thus leaving the body susceptible to infectious and non infectious diseases is no longer a debatable question.

From this point on, we shall have to confine our discussion to the classical occupational dust diseases since this is the area where our epidemiologic techniques are sufficiently sophisticated to demonstrate a causal relationship. Historically, this relationship has been known by observation for over 3,000 years. However, it has only been within recent years that we have been able to place this relationship into biologic perspective. It took the work of many investigators to ultimately arrive at the five cardinal factors involved in the production of dust induced diseases, although in retrospect they appear to be simple relationships. These five factors are:

1. The size of the dust particle must be such that it will penetrate the respiratory system—generally less than 5 microns.

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2. The dust must contain a toxic component; for example, silica or one of the heavy metals.
3. The concentration must be sufficiently great to overcome the body's natural defenses.
4. The exposure must extend over a long period of time.
5. All individuals do not react alike. Some have greater resistance to the disease processes than others or, conversely, less resistance.

Only within recent years has this relationship been taken one step further and developed into a mathematical one which says that given a toxic dust of less than 5 microns, disease is then the product of time and concentration, or D (disease) = T (time) x C (concentration). The formula, of course, has several disadvantages, the foremost being that disease has no definable starting point and, because of the factor of individual susceptibility, would apply to large groups rather than to individuals.

Given a large population and using an arbitrary diagnostic sign as a reference, it should be possible to develop a definable biologic relationship between time of exposure and the concentration of toxic materials. If such a body of knowledge existed, it would be possible to inform a miner after x particle years of exposure that further work in the mines may endanger his health; that after x + y particle years, he has a certain risk of developing pneumoconiosis; and, after x + z particle years, his chance of developing pneumoconiosis is almost 100%.

I trust that the above will always remain in the realm of fantasy for the record-keeping job would be stupendous. Nonetheless, we have come perilously close to such a system on several occasions especially in those areas where environmental controls were neglected.

The formula D = T x C is generally used by the industrial hygienists in setting maximum allowable concentrations. Ideally, the product of T x C should be zero. However, under practical operating conditions, this is not possible. Therefore, time is fixed in accordance with man's normal working span and the concentration is adjusted in accordance with the relative toxicity of the dust under consideration. Thus, prevention of the dust diseases becomes a function of controlling either the time of exposure or the concentration of the dust or reducing the production of the two to an acceptable level.

The traditional method of control in the mining industry has been to limit the concentration of the dust by certain accepted procedures, such as ventilation and the use of dust suppressants such as water.

A recent study of the Public Health Service has demonstrated that a significant number of bituminous coal miners have a disabling respiratory disease commonly referred to as "coal workers' pneumoconiosis." Many questions remain to be answered especially regarding the etiology of the disease. That dust has a significant role in its etiology is unchallenged. Although a similar disease has been known in the anthracite industry for many years, a review of the literature would indicate that the prevalence of pneumoconiosis in the bituminous industry was not very great until about 1950.

The signs and symptoms of the disease are so obvious that it is difficult to accept the concept that the apparent increased prevalence is related to improved diagnostic techniques. However, the apparent increase and prevalence may be related to the increasing use of mechanical equipment underground. Unfortunately, very little data is available which would permit a comparison of dust conditions before and after mechanization.

It is possible that many coal mines may have reached the ultimate in dust control with existing ventilating systems and mine layout. To change either of these factors requires a large outlay of capital which possibly cannot be equated with production gains. Thus we have reached the point where other methods of dust control will be necessary. Certainly the industry has not fully explored what can be done through alterations in machine design. Coal cutting and removing machines were designed to obtain the maximum tonnage in the shortest time period. Another design criteria needs to be added—with the minimum dust production.

All efforts to date have been directed at reducing to a minimum the value of C in the equation D = T x C. The cost of accomplishing this reduction to an acceptable level may prove to be inconsistent with economic returns. Should this prove to be true, then efforts will have to be made to reduce the T factor in the equation. This can be accomplished in one of three ways:

1. By complete automation.
2. Limiting the work time of [redacted] employees.
3. By providing the underground [redacted] with an artificial environment.

Complete automation does not appear to be feasible at this time although great strides are being made to reduce the number of men underground. For obvious reasons, the principle of job rotation to reduce exposure time has never been acceptable to labor or management.

The provision of an artificial environment has the ring of an exotic method applicable to the exploration of space. In actuality attempts have been made to create such an environment by the use of air filtering devices which fit over the nose and mouth. Such devices, generally referred to as respirators, have certain inherent disadvantages such as discomfort, breathing resistance, and communications interference. For these reasons, labor and management as well as the health profession have developed an inanity regarding the potential use of protective equipment.

It is difficult to accept the concept that a total life support system can be provided for a man in space but that we are unable to design a life support system for a man in a hazardous underground environment. It is possible that a major obstacle may be our image of a coal miner. It is difficult to visualize a coal miner looking like anything other than a coal miner. To accept him with the appearance of a scientist or a technician is almost an impossibility.

So far this presentation has avoided a discussion of a hygienic standard for bituminous coal dust. Such a value does not exist in the United States for exposure to bituminous coal dust and until such a standard is developed, the C value in our equation has no significance.

Bituminous coal until recently was considered a nuisance dust and, as such, the ACGIH value of 50 million particles for cubic foot (MPCF) was applicable. Epidemiologic studies have not been conducted in the United States which would permit the establishment of hygienic standards for bituminous coal dust. Research in the European countries tend to support a respirable mass standard rather than one based on particles per unit volume of air. The mass standard which expresses dust concentrations in milligrams of dust of less than 5 microns per unit [redacted] cubic of air has a number of advantages over the particle number standard. Limited observations show a correlation between the weight of dust deposited in the lungs and disease conditions whereas no such correlation has been possible with particle number. In using the mass sample method, dust evaluation is much simpler and instrumentation permits the determination of individual exposures. Most of the European countries are moving toward a mass standard which will likely be in the magnitude of 1.5 milligrams per cubic meter of air.

Only since about 1935 has society in this country recognized that it has a responsibility to those who have developed dust diseases through their occupation. Mandatory compensation was a shocking concept to many when it was first adopted. To others the inadequacies of our first compensation laws for the dust diseases was appalling. In another three decades our present concepts of compensation may be viewed as archaic. European legislation which has established the precedence for workmen's compensation in the United States is tending toward more liberal benefits for workers with pneumoconiosis.

The principle of partial disability is well established in most Western European countries. In the United States the worker affected by a dust disease is often in a less favorable position than a person disabled by an accident or other occupational disease. In many of the laws the time limit that apply to the length of exposure, to manifestation of the disease, and the filing of claims are too short to take into account the slow maturing nature of dust diseases.

Principles for compensation of the dust diseases have tended to remain in a fixed and rigid pattern based on knowledge that is at least a quarter of a century out of date. Such procedures have resulted in practices that are frequently unfair to both parties. Rigid administrative requirements and the concept of compensation for only the totally disabled has doubtlessly been unfair to many workers with bona fide cases of occupational pneumoconiosis. On the other hand, some courts in an attempt to overcome outdated administrative limitations have probably been too liberal in their interpretations.

It is my personal opinion that [redacted] pneumoconiosis compensation laws are modernized, we may face [redacted]

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administering a just and fair system of compensation for the dust diseases. Some of the factors which need to be considered are:

1. A better definition of those disease conditions which are caused by the inhalation of dust.
2. Full recognition of the delayed development of the disease process.
3. Compensation payments based on the degree of disability rather than radiological appearance.
4. Removal of the last employer responsibility concept.

In the last two decades our fundamental knowledge of the dust diseases has progressed further than in all of the preceding centuries. Despite this, the dust diseases continue to be our most costly occupational diseases in terms of morbidity and compensation costs. The greatest reservoir of pneumoconiosis is in the bituminous coal industry.

Despite these advances in knowledge, our preventive techniques have not materially changed in the last quarter of a century. The total elimination of this disease for which we have both the engineering and medical tools represents a great challenge to this profession. However, if the job is to be done, new concepts of prevention and control must be investigated.

WHAT THE COAL INDUSTRY IS DOING TO CONTROL DUST

By GEORGE L. JUDY,
Executive Vice President
Bituminous Coal Operators' Association

The emerging of mechanical mining of coal in the United States, coupled with all the publicity today on air pollution, has brought the problem of dust control to the focus of the mining industry's attention. This problem has been accentuated by the application of the more modern methods of coal recovery by continuous and longwall machinery and by the increase of rock drilling for roof bolt installation.

The industry has recognized this situation with appropriate gravity and has taken steps to apply and advance the technology of dust control. In light of our present limited knowledge of the effects of inhalation of various concentrations of dust over long periods of exposure, current control measures appear to be successful. Should further studies prove that lower dust concentrations are necessary for a healthful atmosphere, the industry will meet those standards by improving current control measures or by developing new technology.

Such studies are now being undertaken jointly by the United States Bureau of Mines and the Public Health Service of the Department of Health, Education, and Welfare with the cooperation of the mining industry. Representatives of the member companies and staff of the Bituminous Coal Operators' Association are officially as advisors to the government agencies involved in this project. Member companies are making available their facilities for dust surveys under actual mining conditions.

The industry has, if for no other reasons than increased comfort and safety through better visibility, applied a wide-range of dust control methods and devices. Stronger measures are being employed or tested where silica dust is involved or where bituminous dust is created in undesirable concentrations.

Silica dust is being controlled effectively by wet drilling or vacuum collectors used with rock drills. Improved cutting bits have simplified these methods of control and the acceptance by workmen of the use of respirators generally has been realized by the publicity given to the recognizable problem of breathing silica dust.

Rock dust standards have been strengthened by the lowering of the allowable limit of free and combined silica content from 25 percent to 5 percent. Reduction of exposure to silica dust has been helped by the employment of conveyor belts and rubber-tired vehicles for coal haulage and for man trips. All told, the industry has found and is applying the means to control the silica dust encountered in coal mining.

The problem of controlling coal dust is, on the other hand, more complex, prevalent, and is confused by the fact that the breathing of coal dust has not been positively recognized with respect to its contribution to respiratory or circulatory ailments. Constant effort is being made to find means of producing less dust in the mining operation and to abate, divert or collect the dust that is produced.

In conventional mining, the use of properly situated high pressure water sprays, in which the use of additives is sometimes beneficial, has brought about a considerable reduction of dust at its primary sources in drilling and cutting. Water-filled PVC bags for stemming blast holes, improved coal shooting techniques, and direct application of fine mist or fog sprays have proven effective in abating dust at its primary source in blasting. Secondary dust sources such as loading and transferring coal also can be controlled by sprays, and roadway dust where a problem by wetting or application of calcium chloride.

One large mining company which began an intensive study of dust resulting from conventional mining upon its introduction in the middle 1930's conducted dust surveys which showed concentrations ranging from 90 to 227 million particles per cubic foot without the use of water sprays during the loading cycle. With the combined use of wet drilling, compressed air blasting, "bug dusting" units and sprays on cutting machines, sprays on loading machines and at transfer points, roadway sprinkling and salting, and with normal ventilation, typical concentrations in million particle per cubic foot were reduced to 14.29 for undercutting and shearing, 9.25 for drilling, 9.49 for blasting, and an average of 7.89 for shuttle car loading, trimming and dumping. This compares with concentrations of up to 268 mp/cf for hand-loading operations in the same seam.

Continuous mining normally results in the production of more dust and longer periods of operator exposure. Here, the methane liberation rate frequently dictates the use of auxiliary face ventilation with its attendant benefits of dilution and prompt removal of dust. Exhausting auxiliary ventilation systems are more inefficient and are less effective for gas removal, but are advantageous for dust removal in that the air current is away from the operator. This has been remedied in various ways, either by use of both exhaust and force tubing situated on opposite ribs with the exhaust inlet inby the blower discharge, or by the use of a hood-fan mounted on the machine that operates exhausting with respect to the direction of air flow.

The most sophisticated innovation for environmental dust control is the cryogenic breathing apparatus which is being [illegible] a major coal producer for use by continuous miner operators. The prototype device consists basically of a portable cryogenic storage vessel bracketed on the machine together with a heat exchanger and a quick disconnect-coupled delivery hose to a breathing mask fitted with a demand type regulator. The quick disconnect and 5-foot length of hose give the operator freedom of movement and exit.

The portable storage vessels are filled on the surface from a blending tank into which liquid oxygen and nitrogen are fed in proper proportions. When charged fully to 75 psi, the vessels weigh 23 pounds. They measure 7 inches in diameter and 23 inches in length and are equipped with a pressure gauge and control valve.

Other methods of providing dust free air at comfortable temperatures to continuous miner operators such as by low-pressure compressors or scrubbers are being explored. None of these devices has had sufficient test to merit complete evaluation especially in light of the unknown degree of the physiological affect of breathing bituminous coal dust.

Longwall mining sometimes introduces significant concentrations of coal dust into the air stream in which certain crew members are exposed. Encouraging results in suppressing such dust by high-pressure injection of water in advance of the longwall face have been experienced at the No. 50 Mine of The Carbon Fuel Company.

Water infusion and other means of wetting and of collecting dust do have the additional benefit of reducing the possibility of dust being raised in the atmosphere in explosive amounts. Auxiliary ventilation, except where dust can be effectively collected or diluted at the end of the tubing, does not have this feature, and where it is necessary to maintain high velocities, float dust will be carried for considerable distances in return airways.

Suspended float dust and precipitated accumulations can be rendered [illegible] by the use of trickle dusters [illegible] introduc-

enough rock dust into the return air stream to dilute the coal dust to an inert mixture. This has the advantage of continuous protection and obviates the need to reapply rock dust in back entries.

Some coal dusts are particularly difficult to wet without the use of additives or increased temperature to lower the surface tension of the water. The principle of increasing the water temperature to improve "wettability" has been used with outstanding results by at least one major company for special applications such as transfer points in tipples and in a long inclined surface conveyor tunnel. They have found that steam jets at critical transfer points will suppress the dust effectively through all subsequent transfer points including final rail loading. There is, however, little encouragement that steam could be used practically in underground coal mines.

Increased ventilation in the last open breakthrough and at the face is still the most common means of combating air-born dust. This is largely because of the close relationship of methane and dust with respect to their rates of liberation (generation) and the necessity to dilute and remove them. Many mines circulate quantities of fresh air several times the legal minimum through the last open breakthrough. Superior quality material for line curtains is now available and is gaining wider use in the industry for conducting air into the working place more effectively. Further, the industry has endorsed the United States Bureau of Mines proposal to revise the permissibility schedule to require that boring-type miners be designed with a 200-square inch cross sectional area for accommodating auxiliary ventilation ductwork.

As described in a paper presented at the 51st Annual Meeting of the Mine Inspectors Institute of America by M. C. W. Connor, Jr. of United States Steel Corporation's Cary Division, a two-split ventilation system developed in that division is being used to control methane and dust and to direct the dust generated at the face away from personnel. This involved development of a mining sequence in which a separate fresh-air split is coursed over the continuous miner and directed to the return permitting the mining of two or three places on cycle. The system made more effective use of the ventilating current at the face by minimizing the use of line brattice and eliminating the need for shuttle cars to travel through check curtains. Maintaining the line curtain ahead of the operator is essential in order to minimize dust in his vicinity and promptly dilute and remove gas.

Little has been done effectively in the medical fields toward the prevention or treatment of silicosis and other respiratory ailments. The "Aluminum Therapy" process involving inhalation of aluminum and alumina dust as a counteractant which was developed by the industry-sponsored McIntyre Research Foundation in Canada has largely fallen into disuse. This is partly because the Foundation required those companies to which it licensed the process to employ extensive engineering controls to abate dust underground, and that these controls, in themselves, were found to be sufficient.

There is some amount of controversy regarding the methods and procedures for collecting and precisely evaluating dust samples. The standard instrument used for years by the coal industry is the midget impinger. The midget impinger has a sampling efficiency of 80-100 percent. Threshold limits for mineral dusts are based on impinger sampling, making the dust counts of such samples directly comparable. The United States Bureau of Mines–Public Health Service dust study proposes to use other types of sample collection devices for both area sampling and for "personnel" sampling. Concurrent impinger samples will be taken in order to establish a basis for conversion of the data collected during the many years of industry study of dust concentrations. The personnel samplers will be used to determine the actual concentration of dust to which various occupations are exposed, at the breathing zone, over a full shift period. The experiment is expected to span a period of several years before meaningful data can be obtained for comparison with clinical studies of respiratory ailments of miners.

In summation, it is apparent that coal dust can and in most instances is being controlled to tolerable levels; and that the industry is willing to meet the challenge posed by studies designed to determine whether coal dust standards should be improved.

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DUST CONTROL AND OTHER SAFETY MEASURES ON A LONGWALL FACE

By H. C. MORTON
Division Supt., The Carbon Fuel Company, Carbon, West Virginia

During the summer of 1963, along with other officials of The Carbon Fuel Company, I visited the longwall faces operating in Eastern Associated Corporation's mines at Kopperston and Keystone. Our purpose was to evaluate the system as a possible solution to roof control and recovery problems in our No. 20 Mine at Carbon, W. Va. No. 20 Mine is in the Eagle Seam and at that time had been operating for a little over two years. The roof in the mine is composed of a strata of very soft and unconsolidated shale which varies in thickness from twelve inches to ten feet. This roof strata can be held very well in entries with wooden headers bolted to the top and timbered, however, when over 60 percent of the seam is mined by conventional room and pillar methods the shale roof becomes hazardous and difficult to handle. Consequently seam recovery was low, not over 55 percent, and the cost of production was about equal to the sale price. No. 20 Mine was about to fail and we were looking for a saviour.

I was greatly impressed with the longwall system I observed at Eastern Associated Mines—it was love at first sight. I felt at that time that the retreat longwall method had the potential of the most economical, conservative and safest method of mining coal. Now, after having been directly associated with longwall mining for over three and a half years, my feelings have not changed.

Of course, the method has not reached the potential—it has probably now only reached a level of evaluation equal to the model "A" Ford in that line of excellent automobiles. As we sang then, "Henry made a Lady out of Lizzy"—we now have something more like a Lady in the line of mining equipment.

No. 20 Mine is now operating three sectional units of equipment. In addition to the longwall unit, one conventional shuttle car unit is used for developing longwall panel entries and one for mining areas of the seam adjacent to old mine workings or crop and property lines that cannot be fitted into the longwall pattern. Although the development section is driving only two entries which is very inefficient, since the longwall went into service, the mine has remained in an economically sound position.

Our longwall face started operating March 2, 1961. On July 1, 1967, the section had operated 1,575 shifts and had produced 1,103,202 tons of clean coal or 700.49 tons of clean coal per shift. Add about 20% for seam rejects and the total material handled was 1,379,077 tons or 876 tons per shift. Operating time for these calculations includes all the time the mine operated minus the time the longwall equipment was moving and being set up. Considering the fact that we have experienced several rather serious roof falls on the head and tail entries and on the longwall face and suffered from other problems which slowed production, we are at least not ashamed of these figures.

Seam recovery as we are presently operating is good. The first panel entries were driven in sets of three entries on 70 ft. centers. The two rows of 51 ft. x 80 ft. chain pillars were left in the gob. While working with these projections we were recovering 83 percent of the seam area between the bottoff and barrier pillar. Now, we are driving only two entries for development. The chain pillar between the entries which is left in the gob is only 17 ft. thick and 78 ft. long, so we are now recovering 96.17 percent of the seam area. Reducing the number of chain pillars left in the gob to one row of very thin pillars not only increased seam recovery but it also contributed to our success with the system by eliminating squeezing in the tail entry and on the tail side of the face.

In my opinion, large non-yielding pillars left in the gob behind the face and between the caved area and solid coal to be mined on the adjacent panel has been the principal cause of the failures in the retreat longwall method of mining in most cases. They will also cause squeezing and bumping in other seams, over and under, when they are mined in later years.

There have been numerous growing pains connected with the retreat longwall system. A lot of learning has been necessary and a lot more is needed before the system reaches

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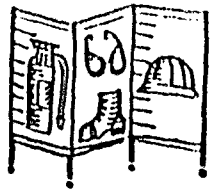

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minimum injury to employees; to promote maximum efficiency; and to effect savings by preventing injury and by reducing interruptions caused by occupational accidents."

The objective was followed by an outline of methods of obtaining the objective: "The effectiveness of the Accident Prevention Plan will depend upon the participation and cooperation of supervisors and employees of all contractors and sub-contractors engaged on this project, and the coordination of their efforts in carrying out the following basic procedures:

1. Planning all work to protect against personal injury, property damage, and loss of productive time.
2. Maintaining a system of prompt detection and correction of unsafe practices and conditions.
3. Making available and enforcing the use of personal protective equipment and mechanical guards.
4. Establishing an effective system of tool and equipment inspection and maintenance.
5. Establishing an educational program to insure the interest and cooperation of all employees through:
   A. Personal example and safety contacts.
   B. Instruction in safety requirements and insistence on compliance with such requirements.
   C. Safety meetings.
   D. Effective use of bulletins, posters, or other safety literature.
   E. Investigation of all accidents to determine their cause and promptly taking the corrective action to prevent their recurrence.
6. Each contractor's and sub-contractor's principal supervisors shall obtain a copy of and shall comply with the Indiana Safety Code for the Construction Industry, and rules and regulations applicable to the work performed by each employer on this project."

Following the outline of six methods to gain the objectives, the responsibilities of the chief project engineer; the safety coordinator; the contractors and sub-contractors; and the job foremen are outlined.

The chief project engineer is responsible for the entire plan as I have outlined it to this point and, in addition, must appoint a safety coordinator, authorizing him to enforce safety measures and to recommend corrective action when sub-standard practices and conditions are observed.

The responsibility of the safety coordinator is to follow all phases of the plan as they have been outlined and in addition maintain adequate records.

The responsibilities of the contractor and sub-contractor are:

1. Comply with all provisions of the Accident Prevention Plan, including attendance at and participation in safety meetings.
2. Appoint a qualified representative with full authority to act on all matters relating to the Accident Prevention Plan.
3. Plan work to protect against personal injury, property damage, and loss of productive time.
4. Cooperate with the project safety coordinator.
5. Comply with the requirements of the Indiana State Code and all other codes relating to his operations.
6. Provide to employees and visitors all personal protective equipment required by the exposure and enforce the use of such equipment.
7. Insure that prompt first aid is administered to an injured employee and transport him to the project clinic or as otherwise directed by the clinic.
8. Comply with all required accident reporting procedures.

The outline of the job foreman's responsibilities include:

1. Setting a good example for the men.
2. Instructing in safe work practices and work methods.
3. Use of proper protective equipment and proper tools.
4. Checking for unsafe conditions and practices.
5. Completely investigating accidents to determine causes and taking all necessary corrective action.
6. Promptly completing required Accident Reports.
7. Holding meetings with men.

The Burns Harbor construction supervision and safety personnel are continually in the construction areas and insist on strict compliance with the Accident Prevention Plan and the "General Safety Rules for Contractors". The fact that the Bethlehem Steel Corporation provides workmen's compensation and general liability insurance to cover approved contractors on the project greatly enhances enforcement of the safety program by Bethlehem and compliance with the program by the contractors.

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Weekly safety meetings a[illegible] held by the craft union stewards, [illegible] committees from these meeti[illegible] with plant protection and sa[illegible] personnel of the Burns Harb[illegible] to further assist in the compliance by all contractors toward the desired goal of maximum safe working conditions.

Periodically, the business agents for the crafts make safety tours of the construction areas with members of the construction and safety departments pointing out various constructive improvements to further improve the program.

Considerable time is spent working with the A.F.L. craft union safety representative to insure a mutual understanding that, for a safety program to be effective, requires the cooperation of both management and labor. Without the complete sincere support of the unions toward a [illegible] safety program, [illegible] only "lip service" for [illegible] with no [illegible] action resulting.

Compliance and cooperation on this project has been excellent. Only infrequently have actions, other than firm reminders, been required to bring the safety program back into line. The aid of the purchasing department is enlisted when the most severe corrective actions have been necessary and this procedure has been most effective.

Our program is not unlike other programs in the construction industry, having the common denominator of planning, motivation, communication, and follow through accompanied with dedicated hard work on the part of each individual on the site. We attempt to implement our program with enthusiasm and a directness of purpose eliminating "lip service" and the attitude "we will look at the problem later".

OCCUPATIONAL HEALTH IN THE CONSTRUCTION INDUSTRY

By FRED OTTOBONI

Senior Industrial Hygiene Engr., Bureau of Occupational Health, California State Dept. of Public Health, Berkeley, Calif.

Occupational health in the construction industry is a subject that has not yet received any real interest or attention in the United States. Articles appear from time to time in the American literature on a specific health hazard, such as lung cancer in asbestos insulators, or lead poisoning in painters. Other than a few papers originating in California, where a start has been made on the heat, noise, and dust problems of heavy equipment operators, almost nothing seems to have been written on the present health status of the individual crafts or on the overall health problems or needs of the industry.

This lack of interest and work is significant. Either there are no problems in the industry worthy of mention, or there is an appalling lack of some vital ingredient which is necessary for stimulating the growth of a systematic interest in the health of more than four million American workers.

First, let's define "occupational health". The term has been so loosely used over the last few years that intelligent discussion of the subject has been difficult. Some people interpret it to mean everything from a cut finger to the social well being of the craftsman's family. For our purposes here, however, occupational health means the prevention of work-caused disease and disability by control of the work environment, [illegible] where both labor and management have a clear responsibility for observation, discussion, and hazard control. This definition requires particular meaning when one realizes that the majority of occupational diseases are not curable; they are only preventable.

Five conclusions have emerged from our studies of occupational health problems in the construction industry. We feel they are fundamental, if progress is to be made. They are the result of nearly five years of observations in California. They dramatically [illegible] the lack of interest, the lack of [illegible] and the lack of action that beset the industry. It is recognized that the i[illegible]

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pressing safety problems in the industry may, in part, be responsible for submerging any concerted interest in health problems. While no attempt is made here to detract from the important responsibility for accident prevention in the industry, it is time that programs in work-induced disease prevention begin to receive the attention they deserve. High accident frequencies cannot, by any stretch of the imagination, justify a lack of interest in healthy working conditions.

Our first conclusion—there is a basic need to recognize that construction workers are now suffering job-induced diseases and that new diseases will emerge with advancing technology.

To the casual observer or even a member of the industry itself, it is reasonable to believe that occupationally-induced diseases in construction work are not a problem. The crafts have long histories of working outdoors in the fresh air with hammers, shovels, and other tools which have in the past traditionally presented safety problems, but not health problems.

A look at the Federal or State health statistics appear to support this concept: not because there is a lack of problems, but because neither the Federal government nor the states—with the possible exception of California—keep any statistics on the subject. When no disease is reported, it is natural to conclude that none exists. However, what appears as no problem is, in reality, no information on the problem.

Experience in California supports this conclusion. In recent years, physician's reports of occupational diseases among construction workers have been coming into the State Health Department at approximately twice the average rate for all California workers. Since 1949, when recording began in California, this rate has been continuously among the three highest of all the major industries. The diseases involve the skin, the lungs, systemic poisonings, hearing loss—essentially the whole range of illnesses normally believed to lie in the exclusive province of factory workers.

Field investigations suggest that more is to come. For example, an estimate based on hearing tests conducted at construction sites by fully-qualified audiologists indicates that some 20,000 heavy equipment operators now working in the state have permanent noise-induced hearing loss. The trend toward larger, faster, and more powerful equipment, designed without consideration for the long-term health of the operator, is expected to intensify this hearing loss problem. It also is expected to introduce silicosis for the first time as a disease of the operators of dozers, power shovels, and front-end loaders.

The equipment operator is not alone in facing these health hazards. **The recent replacement of the plasterer's conventional trowel with a spray nozzle has introduced serious hearing loss problems insofar as the plaster guns that we have measured are concerned. Further, the gun application of asbestos-containing fireproof coatings continues without control and without concern. Yet, data coming in regularly from studies of men working around asbestos dust leave very little doubt that the gun operator and other craftsmen in the area are being subjected to the risk of asbestosis and lung cancer.**

There are many more examples. Plastic adhesive and surfacing materials have made life an itchy nightmare for the tile setter and the cement mason. It is important to realize that much of this skin disease is accompanied by a permanent allergy to the epoxy resin hardener used in the process. The slightest further exposure to the hardener brings on a repeat case of the itch and the man is permanently disabled for any further work with the plastic.

Another example involves today's welder. There was a time when very little except ordinary steel was found on a construction job. An unprotected welder could work with very little hazard from fumes. Alloys are changing this. For instance, inhalation of the fumes from manganese steel will produce an illness which closely resembles Parkinson's disease. Consider also that nickel, cadmium, vanadium, and some other metals are toxic by inhalation.

It is clear that the pick and shovel are gone, and along with them went the fresh air and the iron man. The construction industry has entered the era of machines and chemicals, and it should recognize this.

A second conclusion—it must be recognized that the methods which have been developed for the protection of the factory worker may not be feasible on a construction job.

Most of the occupational health literature and practically all of the preventive methods in use were developed with the factory worker in mind. The factories [illegible] critical industrial health problems of the 19th and early 20th centuries [illegible] where the interest, the research, and the money has been invested. The emphasis today, although comparatively small, is still on the factory. As a result, the standard control methods available in all the textbooks, ventilation, isolation, enclosure, substitution, and personal protection, are organized to make practical and economical sense in a factory setting.

The factory hand works for the most part in a fixed location. Exposure is repetitive and predictable over a long period of time. Utilities are available and control methods can be designed, tested, and finally built-in as part of the company's long-term capital investment. It is not unusual to see a $20,000 ventilation system built into a plant to protect 10 or 15 welders.

But look at the welders on the construction job. In a lifetime, each will have done about as much work and generated as many fumes as a factory welder. However, the control system here is non-existent, because the control methods in the textbooks do not make practical or economic sense on a construction job.

Factory spray painting is done in a ventilated booth, according to the books. Since a booth would cost too much on a construction job, we scratch our heads and spray paint anyway.

Dust, noise, heat, and almost any health problem is controlled by cookbook methods in the factory. The cook book doesn't work for construction, so we live with the problems and hope they will go away.

It is now critically necessary that we accept the fact that a construction job is not the same as a factory job, and that the factory hazard-control cookbook—although free—is not applicable.

A third conclusion—we must begin to develop our own occupational health standards.

The golden era of occupational health in the United States ended in the mid-1950's. The movement which began in the 1930's and provided wide knowledge of industrial diseases and excellent textbooks is slowly dying. The Federal program is small and without legal authority. State programs not only have been declining in manpower, but show little interest in the construction industry. The traditional standard-setting agency [illegible] in the country, the American Conference of Governmental Industrial Hygienists, is dependent upon its dues-paying members for support. Its $13,000 yearly total budget will not cover more than a fraction of the country's problems, and that fraction will be [illegible] pointed.

On this basis, it is unlikely that the [illegible] subsidized work that went into helping the industrialist to understand his problems and to custom-tailor his environmental control will be available to the construction industry. **The facts are that the responsibility for providing a reasonably healthy place to work lies directly with construction labor, and construction management.**

The need for environmental standards is growing with each day. Noise offers a fine example: Heavy equipment, trucks, compressors, chain saws, jackhammers, and a wide variety of power hand tools are producing hearing loss that is reaching scandalous proportions. There are choices. The individual contractor can hire an acoustics expert and modify these tools at his own expense. As another choice, he can attempt to stuff ear plugs in his men, a method that will have no practical value on a construction job, and one that will probably reduce productivity. A popular alternative is to do nothing and let the insurance companies worry about it.

The sensible solution is to collectively write a set of performance standards for power equipment. These can be written right now, from knowledge at hand, and would specify maximum allowable noise intensities at an appropriate given distance from the equipment. The tool manufacturers may have difficulties at first. But their engineering and research departments are available and in the best position to control hearing loss at the lowest possible cost.

[illegible]ate labelling also must be considered. [illegible] few of the materials capable of causing eye, skin, or lung problems such as plastics, paints, welding rods, fluxes, solvents, lubricants, etc., have useful warning labels when they reach the construction site. This has two negative effects, in addition to the potential for injury. First, even the interested men cannot find out how to protect themselves. And second, if the material does cause a problem, the men have no clear information that might be useful in selecting a less harmful product for the next job.

This is particularly dramatized by the experience of the cement masons, where labels are often so vague as to make it impossible for them to determine whether the surfacing material they are expected to apply on a particular job is a dermatitis-causing epoxy, a broncho-spasm-causing urethane, or a relatively safe polyester.

The noise and label problems are straightforward. They follow the textbook closely. Others may not be so simple because of the mobile nature of construction work. Solutions to these will require imagination and money. Ideas from the space program are sure to be useful and we expect to see exploitation of the controlled individual environment in the form of air-supplied suits for plasterers, cement masons, and welders; and air-conditioned, noise-and dust-tight capsules for heavy equipment operators. Standards, once set, can make these easily accessible at mass-produced costs.

The logical approach is to accept the responsibility and begin to develop some standards that can be put into contracts and equipment purchase orders; otherwise the industry faces attrition of skilled manpower, higher compensation costs, hazard pay, and if the problem gets bad enough, the inevitable application of the ill-fitting industrial codebook to these construction jobs.

A fourth conclusion—records and statistics must be kept.

I repeat, health information on working men is scarce. This is particularly so in the construction industry because even the information that is obvious in a factory is clouded by the nature of construction work.

A factory is a relatively permanent environment. Jobs acquire reputations: they smell; old timers get lung disease; this or that chemical will make you sick if you inhale it. This is epidemiology in its most primitive form, done without the help of the professionals or the government. Nevertheless, it is very effective in discovering diseases and developing control methods.

Contrast this with a construction job. The office is often a house trailer and a single craft is not likely to be on a given job for more than a year. Who now is going to do the epidemiology? Work-induced health damage suffered by a craft during the course of a single project very easily passes without notice. It is not until a series of such projects —and you have passed that disability is marked enough to prevent further employment. At this point, cause-effect relationships are obscure. No single event can be held responsible, and the work force has a few less craftsmen. If by some chance the illness is recognized as work-induced, the last employer may be held responsible for the entire cost of compensation. This is no solution.

For example, earth mover operators have long suspected that somehow spinal problems are connected with their jobs. This may or may not be so; there are no statistics. It is hardly possible that all equipment operators are born with bad backs. It is most likely, however, that the vibration and bouncing on some types of seats on some types of equipment are causing spinal damage. Unless it is known, first, whether or not operators are truly suffering spinal problems and second, exactly which machines and what conditions are responsible for the problems, prevention of "back trouble" will be impossible.

With computers now available, it is feasible to record the pertinent details of every job, every illness, and every death for every man working in the construction industry. This should be done by every craft union, with the cost shared by the employer. Routine computer output will then tell us whether painters die young, or equipment operators get silicosis, or plasterers get emphysema, and whether the lung cancer that has been found in asbestos insulators is being controlled or not controlled.

A fifth conclusion—uniform, reasonable regulation must be insisted on.

Competition is very real in construction. In fact, it appears to be so fierce that it often is cited as the justification for poor health and bad safety practices. For instance, the question as to why water is not being used to control dust on a given haul road very often will bring the reply that this is highly commendable; however, "it was not included in the job estimate because the competition never includes such things, and in order to bid the job successfully it was necessary to dispense with the water wagons".

This is a standard answer for many problems. Its effect is to penalize the legitimate contractors and to make the natural growth of healthy working conditions next to impossible. This fanatic interest in cost-reduction seems to be eroding the few existing health standards accepted by the industry.

For example, everyone knows that a sandblaster should wear an airsupplied helmet. This has been accepted without question for decades. Yet during the last year the writer has seen five construction jobs where sandblasters were working. They all religiously wore the proper helmets—but not one had an air-supply hose connected to the helmet! Apparently the air supply isn't being figured into the bids anymore, even though it is still in the law.

Diesel engines in underground construction are an example of long-term, legal erosion. Diesels were allowed underground only after long study and, finally, the setting of rigorous standards by the Bureau of Mines. These included specially designed engines, matching exhaust scrubbers, and ventilation rates based on numbers which accompanied the vehicle from the manufacturer. Competitive progress over the last 20 years has led to the erosion of standards and the acceptance of any diesel vehicle with a home-made scrubber, and ventilation rates based on air sampling methods that have not been proved reliable. The engineered and tested standards and safety factors prepared by the Bureau of Mines are being forgotten. Although a few contractors still use Bureau of Mines equipment, continuous pressure from the industry has eroded the minimum standard. One thing is certain: eroded standards, no matter how legal, neither increase safety nor make diesel exhaust better to smell or less to inhale.

The competitive inducement to save money by shaving health and safety standards need not continue. Good applied health standards, as they are developed under the ethical conclusion noted above, can be made a part of all construction contracts and all labor management contracts. In this way, healthy working conditions will be officially recognized as a legitimate cost of doing business and the toll will be paid in dollars by the buyer of services rather than in the health and longevity of the craftsmen who produce them.

The construction industry has a host of hidden and pressing occupational health problems, with more to come. For the short term future, government rescue does not seem possible and a serious and planned effort by management and labor is badly needed.

The construction industry has enjoyed and become addicted to the privileges of fresh work and fresh air. Change is always difficult. But one way or another, like it or not, the technology that we are using to change the face of the earth will, in the long run change us also.

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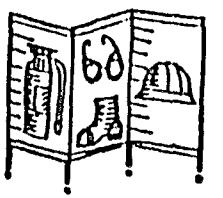

1968 NATIONAL SAFETY CONGRESS

OCTOBER 28-31, 1968 / CONRAD HILTON HOTEL, CHICAGO

1969

1970

1971

1972

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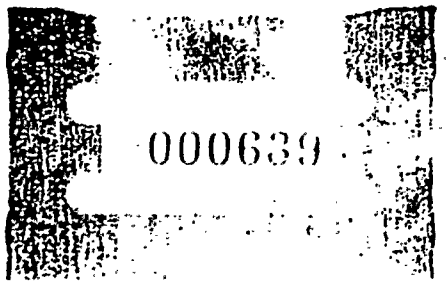
be brought into the picture here. It looks like the Department Superintendent, or Production Manager, or maybe even the Factory Manager, has not spelled out in clear and concise terms just what the Foreman's safety responsibility really is. You will recall that when John finally decided to shut the machine down he stated, "I'll probably get fired for this."

QUESTION: What about Foreman John's language? Is it just "shop talk?"

ANSWER: It may be, but it sure could convey the wrong impression to anyone working for him. I think he would command much more respect as a leader if he talked of and thought of his fellow workers with more respect.



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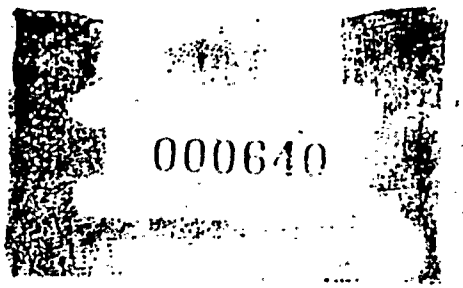

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Electric we find the following three steps particularly fruitful:

1. Acquaint private physicians with nature of work, requirements of Benefit Plan, and function of company medical staff. This has been accomplished by various means, ranging from simple phone calls to plant visits to open houses for community doctors. We find a direct correlation between the amount of familiarity a patient's doctor has with the company and the length of illness absences.

2. Visitation of sick employees to discuss convalescent progress. This visitation may be done by supervision or nurses. In the past we have utilized visiting nurses, but we are having our nurses primarily visit by telephone now. It is still company policy to have supervision visit the employee to show continued interest in the employee while he is disabled.

3. Once a patient is ambulatory, he is asked to visit the company dispensary. The ability of the employee to return to his regular job or to "light duty" can then be discussed between company and private physicians.

Obviously, this kind of close attention to employee's health, and to the work and home environments that contribute to it, can best be accomplished by an on-premise medical force. A company as large as Western Electric finds the effort not only a humanitarian necessity, but one which pays off in on-the-job performance.

The scale of Western's commitment to employee health can be seen in these figures —37 full-time and 99 part-time physicians; health and safety programs at 57 company locations; programs ranging from biomechanics to computerized epidemiological studies, and fundamental research in such varied fields as heart disease and laser hazards.

I appreciate that smaller companies cannot spread these costs across a large employee body. Many companies have found that private clinics can take on this vital medical-management partnership. Others depend on insurance benefit plans—a sure way to prolong absences. Many reports have indicated there is a tendency for length of absences to increase as benefits increase.

Sound management plan is essential to control absenteeism. It creates the psychological and physical environment conducive to good attendance. The cooperation of family and occupational physicians can do much to improve this attendance. This cooperation can restore the ill and injured to work as soon as possible and practice on a broad scale all that we mean by "preventive medicine." Management and medicine can make a contribution to the operating efficiency of the organization. But most important of all, a vigorous medical-management plan is a foundation upon which to build a healthy society on and off the job. As the pressures of our technological age increase, as our urban environment becomes more complex, it is imperative that we bring business and medicine together to seek mutual solutions to health and safety hazards.

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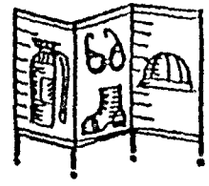

1968 1969 1970 1971 1972

NATIONAL SAFETY CONGRESS

OCTOBER 28-31, 1968 / CONRAD HILTON HOTEL, CHICAGO

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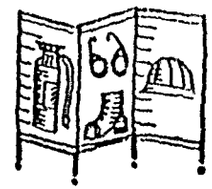

1968
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THE MINER AND HIS ENVIRONMENT

By F. T. M. WHITE
MacDonald Professor of Mining Engineering and
Chairman, Department of Mining Engineering & Applied Geophysics,
McGill University, Montreal

"Environment" has been defined as "the aggregate of physical, regional and circumstantial conditions that surround and influence the life or development of an individual or a community". When this definition is applied to the mining industry, the term denotes something much wider than ground control, mine ventilation, and dust abatement, the aspects of the working environment that have so far received most attention.

The object of this paper is to review, somewhat critically, the total environment of our industry insofar as it concerns those who constitute the productive work-force. It is for this reason that the topic "The Miner and His Environment" has been selected. The paper will, therefore, be in the nature of an analysis of factors and principles relevant to the creation and maintenance of a proper total mining environment, certain aspects of which are seldom examined but which are, in fact, highly relevant.

Mining by surface methods has given rise to little anxiety concerning the physical environment but, as operations have proceeded in depth, more attention to the working environment has become necessary. Most thought has been given to particular functional aspects of the physical mining environment, namely, ventilation and airborne mineralized suspensions. The industry's interest in these aspects of the underground environment is almost as old as underground mining itself. Even in the paleo-metallurgic era of the ancient world, the importance of natural ventilation was acknowledged, and we know from the records of Agricola of the new approaches to induced ventilation (by fire, bellows, and the like) in his day. With our more modern methods, undoubted progress has been made in the physical environment.

In the composite costs of mining, the cost of labor is usually the largest single item and it is through an increase in the efficiency of labor—the output per man shift—that the greatest improvements in this item can be achieved. The initial approach to achieve greater efficiency was to make the working place safer (from the obvious structural viewpoint). From these beginnings, it is now widely accepted that working places should also be more healthful and comfortable and that our mining activities should be designed in such a way that a reasonable performance of labor can be achieved without discomfort. Much by way of increased productivity has been achieved by increased mechanisation, which is reflected by improvement in the man hours per ton of ore mined: in metal mining, from 1.89 man hours per ton in 1952 to 1.09 man hours per ton in 1962 and, in non-metallic mining, from 0.56 man hours per ton in 1952 to 0.27 man hours per ton in 1962. These are significant improvements in productivity. But, mechanisation has introduced additional, as well as its own special, problems. In more recent years, it has become evident that the physical aspects of our industrial environment must be correlated with psychological, as well as sociological, aspects in the establishment of a comprehensively attractive working environment.

The total environment of mining is therefore, I suggest, a composite one of physical, chemical, biological, psychological and sociological elements: together, they constitute the working conditions within the industry—each giving rise to problems of control. In turning to these environmental components, there are some upon which I shall touch only briefly.

Rock Stability/Instability.

"Falls of ground" are a feature of the physical environment that constitute the highest cause of mine fatalities. These derive generally from inadequate safeguards of loose material on the one hand and/or ignorance of the relative stability of the rock structure en masse on the other. Usually, the first of these relates directly to inadequate inspection of the "back" of a freshly-broken excavation and to inadequate remedial action; the second is part of the established practice of ground control and is often the problem of inadequate support at a local[illegible] part of the workings or of [illegible] workings in relation to [illegible] stresses within the rock mass [illegible].

In the past, the approach to the theory and practice of rock mechanics has been largely through the experimental investigation of the physical properties of rocks, the application of stress-strain measuring techniques, photoelasticity, and the like. These have reflected largely a somewhat static approach to the structural problem of rock failure. It might well be that a more dynamic approach can be envisaged (through "geodynamics"), involving a change in emphasis through concepts of inherent instability rather than of apparent stability of excavated structures. In any case, much more still remains to be done in correlating the influence of design and layout of workings with the stability and instability of the rock structure. This is largely a matter of mining engineering control involving a knowledge of the structure and the principles of ground support by the judicious design of pillars or use of support materials (such as timber, concrete, "fill", etc.). The aim is towards complete extraction of the economically mineralized material. We have yet to learn much more concerning the mechanisms of "fill" consolidation (either by normal compaction or the use of cements and other chemical mixtures), the method of attaining uniformity in properties, and the subsequent rock mechanics of the consolidated material.

The non-engineering interest is a statistical one—statistics and classification of accidents caused by "falls of ground". "Fill", in the form of the coarse fraction of comminuted material, is now a common form of ground support and, apart from certain minor aspects (such as chemical reactions producing carbon dioxide, sulphur dioxide, and other gaseous contaminants in small amounts, and/or the presence of residual polluted water), presents relatively minor non-engineering problems.

Mine Air Conditioning.

The term "mine air conditioning" has been deliberately used, since, in the matter of atmospheric environmental control, we should be concerned with the simultaneous control, within prescribed limits, of the quality, quantity and temperature-humidity of the air within a designated space or in a designated circuit. Fundamentally, ventilation is concerned with air quantity or air movement; many tend to think of air conditioning as being concerned principally with temperature-humidity. Our concern should be the simultaneous control of purity, motion and heat content of the air. In the past and often today, too little attention has been, or is paid to this essential simultaneous control.

Thermal exchange between the human body and the environment depends upon four external physical factors: air temperature, radiant temperature, air velocity, and moisture content of the air; but thermal exchange is also subject to delicate physiological controls through variations in the metabolic rate, the rate of chemical and oxidation processes within the human body. The four physical environmental factors are independently variable and may be combined in different ways to produce the same thermal effects upon man: an increase in air velocity will offset a rise in air temperature; a considerable elevation of air temperature can be tolerated if the relative humidity is less and so on. Such combinations of thermal conditions that induce the same thermal sensations are called thermo-equivalent conditions. The normal and basic Effective Temperature Scales give the combinations of equivalent conditions as determined by dry bulb temperature, wet bulb temperature, and air velocity. Thermal comfort in the environment is the primary purpose of air conditioning. Inasmuch as man generates heat and is comfortable at environmental temperatures below body temperatures, the problem generally is one of controlling the heat lost from the body, not the problem of heating the man. Nevertheless, in order to maintain an environment that will regulate the loss of heat from the body, it may be necessary to supply heat or humidity, to cool or to dehumidify, or to vary the velocity of the air movement in the area. Most applications underground will require the consideration of more than one of these to arrive at a satisfactory environmental condition.

In North America in winter, the addition of heat to a ventilating system is of [illegible] tial. Briefly, the addition of heat is [illegible] attained either by radiation, the transmission of energy by means of electromagnetic waves of very long wavelength; or, more commonly, by convective heat transfer by either natural or forced circulation of the air around a heat source. The possibilities of heat exchange by other [illegible] obviously than direct heat utilization [illegible]

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inde: waste heat from nearby installations, warm return air from other underground workings, geothermal heat from rock at depth, or the heat contained in large bodies of water in lakes and rivers (even beneath ice-cappings in winter). In deep mining, as at Kolar (in India), or on the Witwatersrand, or in Northern Australia, heat removal from the air stream is necessary. For this evaporative cooling is used or, alternatively, the air is passed over chilled coil systems. Although we read of the rare case in mining that calls for humidification of an air stream, dehumidification is frequently more desirable. The ultimate and eventual limitation in modern mining is depth, in which the problems of heat, largely through geothermal gradients, can be very serious. Combined cooling and dehumidification processes have become necessary to provide desirable environmental conditions in some mines. Avoidance of humidification is attempted by resorting to dry drilling and a reduction in the use of water wherever possible, but such practice in turn gives rise to other problems.

Quality control of the environmental atmosphere has not received as much attention in metal-mining as it has in collieries, but a greater awareness is evident nowadays amongst metalliferous mining engineers responsible for mine air-conditioning. The use of electrical analogue computers offers a rapid means of simultaneous control of a number of factors. Much remains to be done in the study of turbulent resistance to flow in mine air streams and in the development of methods of ventilation network analysis.

Acclimatisation is a factor in environments which claims our attention in the industry under certain conditions. The extreme heat at extreme depths of mining give rise to problems of heat tolerance of the individual and, with these, those of acclimatisation. The adjustment of miners to extremes of environmental heat may be prolonged and, even when acclimatized, gradual lowering of the overheated body to normal temperatures is important. Acclimatisation is also necessary in the case of high altitude locations; for example, in the Andes at elevations of 14,000-16,000 feet, where it takes the form of adjustment to oxygen deficiency and avoidance of over-exertion. Acclimatisation is a personal adjustment in the approach to, and withdrawal from, these unusual environmental condi-

Dusts and Radiations.

The hazards associated with dusts and radiations are amongst the most serious of all those with which the mining engineer must contend but, like ventilation, have been receiving increased attention in recent years, particularly since the insidious effects of radiations have been dramatically demonstrated in the uranium mines of this continent and elsewhere. Although much work has been done on this important subject, much still remains to be learned concerning dusts and radiations.

The dust hazards derive from combinations of particle size range, freshness (or surface reactivity), composition, and the susceptibility of the individual exposed thereto. Dust particles of pathological (or combustible) consequences are predominantly below 10 microns in size; that is, less than .0004 inch. Particles larger than 10 microns are unlikely to remain in airborne suspension in air streams of even moderate velocity. The hazardous dusts characteristically have a mean particle size in the range of 0.5 to 3 microns, and generally the chemical reactivity of the mineralic material increases with decreasing particle size. Dusts below 10 microns, having no significant weight or inertia, tend to remain suspended somewhat indefinitely in an atmospheric environment. On the other hand, we know so little about actual dust particle behavior, particularly of the fibrous types such as asbestos—fine tube-like structures of almost constant diameter (0.5 micron) but of varying lengths. Do they tend towards preferential concentration, wafting about in the atmosphere and settling under "hindered" conditions? How do we assess atmospheric concentrations of such dusts with accuracy? Since dust particles may be electrically charged, can they, or do they, attract to their surfaces coatings of even finer, more fissile dusts in parasitic fashion? Is this the reason for the intense activity of some essentially silicious dusts (as on the Rand and elsewhere) where pneumoconiotic symptoms appear to have been accelerated by some agency, perhaps extremely fine radio-active coatings? These are questions that still remain to be settled.

There are a number of categories into which dusts can be classified: (a) pulmonary dusts, which are harmful to the respiratory system (such as silica, silicates, beryllium ores, iron ores, and cassiteritic ores); (b) toxic dusts, which are poisonous to body organs and body tissues (including arsenic, lead, mercury, radon, thorium and others); (c) radio-active dusts, which are injurious because of their radiations (ores of uranium, thorium, etc.); (d) explosive dusts, which are combustible in airborne suspension (coal dusts, sulphide dusts, and the like); and (e) inert dusts, which allegedly have no harmful effects. Some dusts have multiple ratings and, as our experience grows, more and more dusts are being added to the harmful lists; there is, in fact, increasing reason to doubt whether any dust is really inert or pathologically harmless.

Dusts can vary in their injuriousness when associated with gaseous contaminants which, in their own field can have adverse physiological effects through asphyxiation, toxicity, or radio-activity. As with oxygen depletion, the physiological effect of a gas varies with the exposure time and the individual. Radon, because of its decay products, gives rise to particular problems of surveying and assessment. A vast amount of work has yet to be done on the sources of radon, its migration in mine waters, and the mechanisms of its release into the working atmosphere. Can its solubility differential in water and oily liquids be put to beneficial control use? Its disastrous assimilation in the blood stream is based upon this marked solubility differential.

Generally, in our assessment of the harmfulness of industrial dusts, several factors emerge as important. Mineral composition is probably more important than chemical composition, and the physio-chemical properties are probably more important than the physical properties. The surface activity of particles is important. Permissible concentrations vary from dust to dust. Radio-active and other toxic dusts can be harmful at concentrations less than one-fifth that of a traditionally accepted harmful dust, such as silica. Exposure times are found to vary enormously. In some cases, silicosis has been diagnosed after less than one year of exposure; in other cases, only after 15 or 20 years or even longer. Radiation damage generally does not make itself obvious until after several years. Even in a single mine, are there variations in the silicosis-producing properties of quartz at various depths? This would appear to be so. For example, at Kolar in India, with shallow depths, classical silicosis was rare even in mines with a lifetime of underground [illegible]ment; [illegible] exposed, silicosis [illegible] to appear [illegible] years and now, with depths of the [illegible] 11,000 feet, silicosis is expected to [illegible] ous hazard after less than five [illegible] derground working [illegible]. The [illegible] of particles, whose surfaces [illegible] coated with highly active film [illegible] dusts, has yet to be fully investigated.

In any case, the mere presence [illegible] and/or radiations has an adverse [illegible] cal effect upon miners. From this [illegible] alone, their abatement is important. All [illegible] have nuisance value, in that they [illegible] visibility, create uncomfortable [illegible] tal conditions, and result in labour [illegible] and dissatisfaction.

The subject of abatement still [illegible] adequately studied. Water has been [illegible] versally applied medium, but its efficiency [illegible] open to question and it has been found, [illegible] example, in certain winter time [illegible] tivities, wet drilling is virtually [illegible]. Newer methods of abatement must be [illegible] tigated. Efforts have been made [illegible] electrostatic concentration to [illegible], but with only partial success.

Some are of the opinion that other methods should be investigated. Should [illegible] applying to airborne mineralic-[illegible] pensions the same sort of principle [illegible] apply to water-borne suspensions [illegible] dressing processes? Is it possible to [illegible] dust surface activators which would [illegible] the dust particles more amenable [illegible] tion and, therefore, abatement, by [illegible] froths and foams? This is one field [illegible] allic surface chemistry that could be [illegible] tant. It might offer [illegible] solution [illegible] age-old problem.

Mine Illumination.

Inadequate attention has been [illegible] to mine lighting. Although spectacular advances have been made in illuminating engineering, our industry has been slow to take advantage of the new developments. Almost any handbook on illumination [illegible] sible to find tables which list optimum illuminating conditions for [illegible] trial activity, with the [illegible] mining.

To say that lighting has always been a problem underground, [illegible] leaves much to be desired, is an understatement. [illegible] Any new application [illegible]

the ability of the eye to adapt itself to adequate visibility at relatively low illumination and brightness levels. Generally, we are confronted with poor natural reflectivity from the rock surfaces of our mine environment, and this means low eye adaptation.

Paucity of data from mining operations makes it difficult to prove conclusively the beneficial effects of improved illumination. The direct effect of lighting on underground efficiency as reflected by "cost per ton of ore" or by "output per man shift" has not generally been studied and the indirect effects (for example, the raising of personnel morale by improving the brightness of the working environment) are still considered largely speculative. Improved lighting undoubtedly improves worker psychology and morale in surface activities and there is no reason to suppose that similar results cannot be achieved underground. Total injuries in surface mining operations are a fraction of the total accidents in underground mines. There is therefore some satisfactory conclusion to be drawn concerning the merits of good natural lighting in the surface working environment when compared with poor illumination conditions underground.

Better underground visibility should reduce the total mining accidents, of which a large proportion are concerned with dexterity and mobility, both of which call for coordination of the visual process with bodily movement. Visual performance deteriorates with advancing age, and such deterioration can best be countered by improved environmental lighting. Fatalities generally are higher in the older age-groups of underground miners, despite the fact that company policy may ensure younger men being employed where greater alertness and dexterity are called for. On the surface, where visibility is better, fatality rates decrease when the older men are given less arduous and less dangerous tasks progressively with their age. Even where accidents to older men may be due to a combination of attenuated reaction time, reduced dexterity, and slower movement, data show that better visibility counteracts this. Adequate visibility undoubtedly assists in the avoidance of accidents associated with increased mechanization and contact with moving equipment.

In considering illumination, we should take as our criteria the combined effects of illumination and all of those factors which control determine visibility. This will call for a new approach to "mining visibility", but it should achieve more worthwhile results, with minimum expenditure, than continuing to apply popular ideas based solely upon illumination levels and the number and intensity of lamps installed.

The term "visibility" is used to denote the ability of the eye to receive a visual impression; "visual performance" involves interpretation by the brain of the visibility stimulus that it receives and the outward muscular reaction which results therefrom; in other words, reaction time is a factor. There are four important factors that effect visibility: (1.) the size of detail to be seen, (2.) the time available for seeing, (3.) the lighting and color contrast between the observed object and its background, and (4.) the brightness level of the visual field. To some extent, these four factors are interdependent.

The adequacy of underground lighting calls for an appraisal of the task characteristics involved in terms of visibility. The "visual task" not only involves the nature of the job itself but the lighting environment provided; that is, details of the size and shape of objects to be seen, their relationship to background and surroundings, and so on. These must be assessed, along with the general aspects of the lighting environment, at the time of observation in order to define the visual task.

Visual tasks are placed into three categories: (1.) teloramic, in which the important objects are at a viewing distance greater than six feet; (2.) mesoramic, in which the principal objects are less than six feet, but not less than 12 inches, from the eyes; and (3.) ancoramic, in which the tasks concerned require close viewing distances. In mining operations, the ancoramic tasks are few but nevertheless important (inspection of a working face for structural features, underground surveying, and so on) but the majority of tasks are teloramic or mesoramic. However, seldom in mining can we consider the problem solely on the basis of one visual task. The viewer performs a number of different tasks and, even when his principal job involves work at close range, there will be the need also for long range vision.

The analysis of underground visual tasks is therefore not an easy one. Fortunately, the procedure is simplified in that many of the tasks underground do not call for concentrated detail (such as would be necessary in, say, precision machining in a worksh

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and there is little difficulty in determining critical detail in order to perform the task satisfactorily.

Nevertheless, because we use point sources of portable light, much of the visual field in mining is not illuminated at all and we find ourselves asking not "How well can I see?" but "What can I see?". There is obviously a need for more general illumination. Expanded use of flood lighting in the general underground environment helps tremendously.

Many attempts have been made to measure the ease and ability of seeing and to produce an "index of visibility". One promising instrument is the Luckiesh-Moss visibility meter, used to determine the relative visibility of various objects and evaluate the visual task. The instrument observes a portion of the visual field against its background and compares it with the brightness of a threshold value when the field is only just discernible. A great deal of work remains to be done in applying the principle to mining.

One approach would be to divide the visual task into its essential components: contrast, size, time, brightness and "emphasis", the latter being a factor that takes into account the degree of mental concentration necessary to perform the task. Certainly, research should be directed at establishing some basis for visual performance of underground tasks in a properly illumined environment.

Travelling ways have probably received closest attention but much depends upon the service being performed. Although lighting may be adequate to observe the approach to an ore train, the illumination is often so irregular and inefficient that men are unable to discern the uneven nature of the floor or the presence of loose equipment lying about.

The continual change from dark to light conditions, particularly in passing from travelling ways to work places, creates not only psychological but physiological problems for some individuals. It takes some time for the eyes to become adjusted to transitional lighting conditions. When an individual moves quickly from a lighted environment to one which is less bright, there is an adverse effect upon visibility before the eyes become completely adapted to their new environment.

Lack of uniformity in the visual field creates other problems due to the fact that the eyes tend to fixate points of intense light. When these points do not coincide with work under observation, opposing one must overcome the eye's tendency to look away from the work toward the light source. This is a frequent cause of discomfort and fatigue. It is something that we have all experienced underground when talking to someone wearing a cap-lamp. Eye "dazzle" was once thought to be caused primarily by excessive use of the eye pupil's control of vision, but a more common cause of fatigue is the tension that arises when opposing muscular movements are stimulated, thus creating a conflict.

Indirect lighting is the best method of producing uniform illumination. One disadvantage is its cost, since considerable light is lost through absorption and poor reflectivity. Lighting is a fertile field for mine research. Good lighting is cheerful and stimulating and, in many cases, improved practice can be attributed to improved lighting.

Noise and Vibration.

Airborne sound is due to variations in atmospheric pressure and, for a simple tone, that is, a sound characterized by a single note of pitch—the number of times per second that the pressure changes through a complete cycle is the frequency of the sound. The assessment of sound is on the "A" scale.

Most people feel annoyance when confronted with a noisy device or in a noisy environment; in mining, we have both noisy devices and noisy environments. Subjective distress often diminishes as the worker continues to work and comes to accept the noise as a natural background to his task, especially when he himself contributes to noise through his job. This is particularly applicable to the operator of a rock drill.

Nevertheless, we are reliably informed that part of the adaptation of the worker to the disturbing noise involves the expenditure of extra energy in his responses and he is advised to pay more attention to the relationship between personality traits and susceptibility to distraction from noise. Those who are bored or maladjusted or who find their work uninteresting or difficult frequently complain about the distracting effects of noise in their environment; in many instances, their complaints are simply rationalizations to excuse the lack of [illegible] themselves and to others.

Nevertheless, we [illegible]

reactions to noise, because it is known that the accumulative effects of prolonged exposure are physiologically dangerous, through loss of sensitivity to tones, through deterioration of the hearing function of the inner ear, and eventually through permanent audiometric damage. Psychological factors are also involved.

Certainly, noise serves to distract and reduce the effectiveness of a worker and decrease his output. Intermittent noise is the most obnoxious, particularly during any period of adjustment to a new task or in new surroundings. Evidence indicates that, if a worker remains in a noisy situation which distracts him initially, he may eventually adapt to it, and regain his original loss of output. While this may be so, the fact is often wrongly interpreted to mean that, in the long run, continued exposure to noise does not have any adverse effects. Such a generalization is definitely unjustified.

Some investigators have found that the effect of noise on work output depends upon the nature of the work; a long term job requiring constant vigilance is especially susceptible. The effect of noise is more likely to be a higher rate of errors and accidents rather than an actual reduction in total output. The attention of the worker wanders from the job in hand more often as the noise level increases. Further, noise is more likely to lead to increased errors and accidents if its value exceeds 90 db., and high frequency audible noise is more harmful in this respect than low frequency noise.

Noise and its effects have given rise to much controversy in industry. How dangerous can it be? Has it a deleterious effect upon worker performance? Does it effect certain types of work more than others? Has it a detrimental effect upon worker adjustment?

The intensity noise level is probably the most important single factor in determining the severity of exposure, but the duration of exposure is also important. The threshold level of noise that the ear can withstand for some time without audiometric damage is of the order of 90 db. Since the average pneumatic percussive rock drill produces some 120-130 db., the problem is not one to be brushed aside lightly.

The underground mining environment has become progressively so noisy that speech communication in a confined area is difficult if not impossible and, for this reason, speech interference levels are evaluations of importance. The consonants contain most of the informative values in speech but unfortunately they are more readily masked than vowels because the consonant sounds are weaker. Noise may therefore mask certain speech sounds and not others. The energy of the various speech sounds is distributed over the frequency range of below 100 to above 10,000 c.p.s. The "s" in speech has an energy range of from 4,000-8,000 c.p.s.; in contrast, most of the "ee" in speech is distributed below 4000 c.p.s. Such variations in sound frequencies account for failure of speech communication in noisy environments.

Insofar as industrial noise is generally unpleasant, it may be assumed that its correction will lead to better worker morale for the same reason that any consideration for the welfare of employees tends to produce a favorable reaction. Intermittent, high pitch, and high intensity noises are the most disturbing so far as emotional reactions are concerned. Some individuals are hypersensitive to noise and cannot make effective adjustment.

Ear defenders will invariably serve a useful purpose, but it is difficult always to "sell" the principle. Personalized ear plugs, cast for individual ears, are probably more readily acceptable. The use of mufflers and machine enclosures have proved partially effective in reducing noise levels in practice, but the noise surrounding even the muffled rock drill is still dangerously high. The greatest advantage in relation to rock drill noise abatement will probably be made through improved design of the equipment and the application of human factors engineering.

In every mine, some staff member should be responsible for the noise hazard. He should be equipped with noise and peak level meters, an octave band analyzer, and other standard equipment and he should be trained in their use and in interpreting their data. Periodical noise surveys should be carried out and steps taken to mitigate this nuisance to personnel, impediment to production and menace to health. In many cases, simple remedial steps are effective: others present topics for research. Of particular interest, and something we know little about, is the influence of reverberation upon noise levels from machines and at the operator's ear: this is of importance in development ends, rises and other headings.

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Closely allied to noise is the problem of vibration and its effect upon the body and his various parts. The human body is a mechanical system of considerable complexity. It has a very limited passive range and, in the presence of vibration, its role is usually passive. The physical effects of vibration on man are primarily mechanical, effects that produce motion and relative displacement and which may result in injury.

Biologically, the body responds to stimuli presented to its receptor organs and, of these, the nerve endings are adversely affected by vibration. Piston-operated pneumatic tools produce significant problems, due to their vibrations which vary, as the strokes, from 250 to 6,000 per minute. The heavier the tools usually the slower the vibration rate. The "throw" of the machine also comes into question. Mechanical tool vibrations can produce occupational disorders by injury to the soft tissues of the hand (particularly the palms), impairing the function of joints in the arms (the elbows more than the wrists and the wrists more than the shoulders), and creating vascular disturbances (evidenced by intermittent pallor or cyanosis of the extremities, the fingers in particular). The latter is known as the Raynard phenomenon, which is liable to be present in miners, riveters and the operators of vibrational tools generally. Vibration rates of 2,000-3,000 per minute appear to be the worst offenders, but much still has to be learned about the severity influence of the "throw" of the machine.

Human Factors Engineering and the Environment.

In recent years, attention has been turned to the co-ordination of machine design and human adaptation to the machine itself. While the ultimate, though unattainable, goal would be for equipment and methods to be developed for each individual operator, the more practical view obviously is that optimum conditions should be discovered and incorporated in the design of equipment for groups of workers. As work becomes more physically demanding, accidents may be expected to increase. The importance of work speed as a factor in safety is frequently under-estimated. Ordinarily, with more strenuous operations, the speed of work falls off considerably towards the end of a working day and, as a result, accidents may not be as high from this cause as they otherwise would be, unless physical fatigue intervenes. However, working speeds during certain operations are sometimes clearly uncongenial with the capacities of the operator. With slow speeds, the worker may become impatient, and fast speeds may distract him because of his inability to keep up with it. In either case, accidents can happen. One of the most important concepts in human factors engineering is the design of equipment in terms of human capabilities and limitations.

Difficulties arise when the control mechanisms becomes too complicated for normal human actions. With an increase in work-productivity tempo, it follows that everything must be done to design the equipment and to set up the operating procedures so as to facilitate the greatest possible efficiency and safety. These are the aims of human factors engineering, the application of which can have a big influence upon the future working environment. There are several points that can be more precisely stated: first, the designing engineer must have an understanding of the sense organs and the characteristics of human perception and response if a satisfactory operator reaction is to be obtained from sounds, lights, meters, and other media in the operation of equipment—man himself is a poor monitor of equipment; second, the designer must not place unreasonable demands upon the operator (in, say, reaching and operating a control or a lever, or in clearly differentiating between two or more controls); third, the designer must bear in mind that the operator may not always be at his peak but may suffer from temporary impairment of functions (through, say, fatigue) thereby causing inefficiency, and that there may be changes in functional activities as a result of aging; and finally, the environmental conditions in which the equipment and operators are to operate must be studied and thoroughly considered.

Attributing accidents to human factors alone has sometimes been over emphasized. Often, the underlying cause of the accident can be traced to poor or inadequate design of equipment, particularly in relation to the controls. (It might be pointed out that greater consideration could be given to the design of controls in certain types of rock drills from the viewpoint of avoiding back damage to the operator at various operating positions. Experiments have shown that, in some machines, there are other than

and" positions that would be less hazardous in regard to noise reception).

The working place is only one aspect of the mining environment. The machine is another and often an equally important one. It follows that special consideration should be given to range, strength, speed and accuracy of bodily movements in relation to the design of machines, including their shape, size, direction of movement, speed, and the location of their controls.

The Psychological Mining Environment.

At one time, work was regarded as a physical phenomenon and productivity was the outcome of the application of physical energy but men are no longer considered to be mere machines. We expect and receive productivity through a combination of mental and physical work. Mental work refers to that form of achievement in which remembering, thinking, reasoning and judging are contributing elements, and physical work embraces those activities where speed, coordination, and intensity of muscular response are the main concern of the individual. Mining is one of those occupations where a combination of both physical and mental coordination is called for and, in many cases, it is impossible to separate the distinctive contributions made by the respective factors.

The most readily observable effects of physical activity on the individual are increased breathing rate, pulse rate, temperature, blood pressure, and oxygen consumption, and it is towards these physiological changes that mine air conditioning and other physical environmental controls are directed.

Productive efficiency is bound up with both energy output and fatigue. Physical fatigue is derived from sheer physical causes and momentary "blocks" in an individual's output can be ascribed to his general physical condition; but we cannot overlook the mental aspects of fatigue, one of which is boredom, when the individual feels that his work presents no challenge and when his interest in the immediate accomplishment of that work disappears. When this happens, he ends up in a motivational conflict and his productivity suffers.

The problems of mental fatigue that arise from repetitive activities are not as pronounced in mining as in some other industries. Nevertheless, they should not be overlooked. An example from coal mining in the United Kingdom is perhaps of interest. The psychological effect of mechanization had been noted in the longwall mining of narrow seams, with the same monotonous operations being repeated several times a shift. This applied particularly to the power loader operator who was called upon to travel to and fro along the longwall face. Difficulties and dangers from boredom arose, but were overcome by arranging for the loader operator to change jobs with one of the "stable" men at the end of each face traverse. The importance of such psychological factors in accident prevention is well-recognized.

Effective motivation can create a highly desirable mental and psychological environment and, for this reason, factors in the motivation of a mining work-force demand closer attention than they may have received in the past. Motivation of an individual can be very different from motivation of a team. Today, men function both as individuals and as team members and, in industrial team relationships, the psychological factors involved can sometimes be used as criteria for evaluating productivity.

Productivity varies from worker to worker, and an individual worker's production may vary hourly, daily, or weekly; how much he produces is influenced both by his physical condition and by his psychological attitude to employment. Differences in production rates between groups of workers are usually greater than differences among the individuals forming each specific group. When variations in achievement and response vary from group to group comprising men of comparable skills, some of the variations can be attributed to the groups themselves. Perhaps one group has been accorded more self-direction than another, or in one group some individual emerges as a leader. In other words, some groups become teams more so than others.

The increased working solidarity within the group often extends to increased solidarity in their off-work activities. This sort of thing could become very important in the sociological problems of an isolated mining community. But, group productivity may suffer, if sociological factors are ignored or treated as unimportant—in spite of incentive payments that could normally be expected to stimulate productivity.

Studies in the efficiencies of large versus small mining work organizations have been undertaken overseas. Some time ago, re[illegible] was made of the comparative success

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small mines, particularly collieries. Lower accident rates and increased productivity were ascribed to a higher ratio of "managerial supervision". Current studies tend to show that the beneficial effects established under these conditions can be applied to the re-organization of larger mines. The principal change that has been recommended in the existing organization of large mines is the strengthening of on-the-job supervision or "management", by recognizing the working face as the basic unit of production and by building from there a structure which limits the size and diversity of any one level of managerial supervision. It has been suggested that, from a human viewpoint, very large mine organizations would function better if they were, in effect, a collection of smaller mines, each with a sense of individuality and purpose.

In such ways as these human relationships, both individual and group, are being vastly improved in the United Kingdom coal mining industry. The individual worker feels closer identification with the job and the supervisor "senses" better control of the operations. It has been contended that organizations can perhaps become too large for the individual worker to develop any sense of "belonging", which is an essential element in full worker cooperation.

At this juncture, I wish to refer momentarily to the psychological aspects of accidents and of safety consciousness. The psychological facets of the accident environment should receive much closer attention. The mere adaptation of breezy accident prevention slogans and the competitive registration of lost time statistics are not good enough. The "grid" theory, that was originally designed for managerial interpretation, has been found to be applicable to supervisory responsibilities and, it is suggested, could be equally effective in its application to safety training programs.

The role of the supervisor is extremely important as an environmental factor. Is his to be an emphasis centered only upon higher productivity? or is it to be an emphasis on his subordinates' welfare? or is it to be a blend of both? The role of the supervisor in mining activities is distinctly different from that in other industries. He is confronted with widely-spaced work points, difficult of access, in unusual conditions of rock structure, of lighting, of noise, and the like; his is a network of supervisory activities. It is his job to maintain high morale and high productivity [illegible] together.

The Sociological Mining Environment.

Let us turn momentarily to the [illegible] cal aspects of our mining environment. Instead of studying human behavior in terms of individual or personal behavior, sociology is the study of social relations between people, in terms of value systems, division of labor, authority patterns, [illegible]. There is more to the behavior of human beings than can be explained in terms of individuals. The statement by Barnard should be noted: "Any industrial organization performs two major functions: the economic one of producing goods and services, and one of creating and distributing human satisfaction among the people making the contribution. If the company's human organization is out of balance, all of the efficiency experts in the world would not improve the economic [illegible]."

With the introduction of new mining techniques and technologies, it is important that consideration be given to both the social and psychological consequences of innovation. Even with existing methods, the sociological influences should be recognized. Very little work appears to have been done on the sociological aspects of the mining industry on this continent. The little that has been done should be studied. For example, an analysis of the psychiatric studies in the Eastern Kentucky coal mining communities is rewarding.

But studies of considerable significance have recently been conducted in the United Kingdom and are being continued. One interesting study concerns the introduction of mechanization to replace the old hand-winning methods of coal mining. In many cases, a change that was technically efficient was only partially successful in its effectiveness because it cut across social relations. These difficulties have generally been overcome through the development of more strongly-knit primary work groups.

A somewhat related study of the connection between workers and their psychological interests is also available. In [illegible] safety has long been a problem in mining, where safety depends upon the alertness of individual and inter-group responsibility for the working conditions by workers (who follow on the [illegible] close group feeling could [illegible]

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With mechanization, accidents showed a serious increase and it was considered that the disruption of social groups by mechanization might be a major cause. In an attempt to correct this problem on the job, management took steps to rebuild the social organization of the work group off the job by recreational incentives. At the same time, they emphasized the interdependence of the shift groups and the social organization of the mine as a whole. Within less than a year, the accidents in the mines handled in this manner decreased significantly in comparison with similar units that did not follow these policies. The sensitivity of social factors both on and off the job should be properly studied and applied effectively by management.

In the evaluation of productivity, the economic, mental, and social environment of the worker must be taken into account. At one time, industry tended to concentrate almost entirely upon "economic considerations"—the amount of product, the quality of product, wastage, errors, damage, lost time, compensation claims, and so on. Some attention was then given to the "physiological and physical demands" on the industry—safety and injuries, short term illnesses, permanent effects on health, absenteeism, and so on. In more recent years, "psychological considerations" have been receiving some attention—fatigue, emotion, monotony, job pride, work satisfaction, motivation, personality adjustment, etc. Now, industry finds it both necessary and advantageous to include "sociological factors" in its considerations—worker adjustment, family contentedness, levels and standards of living, cultural and social amenities, the impact of adolescence, the problems of isolation, and the like.

The Mining Community and the Mining Environment.

The mining industry of both Canada and Alaska is a powerful factor in the development of those countries. Many mining communities, particularly the newer ones, are essentially single enterprise in their concept and are usually located north of the strip of settlement along the U.S.A.-Canada border. These communities, which constitute "isolated mining environments", are destined to play an even more significant role in the future, particularly as the mining industry itself expands and extends its frontiers further northward.

Such mining communities present certain special environmental features that may affect the working and social lives of the community—the miners and their families. In their development and structure, these communities follow broadly the same pattern as the mine that they serve: the reconnaissance, the development and, finally, the productive or mature, stage of establishment, in each of which management, in its relation to the community work-force, can face problems differing in scope and in intensity.

The composition of these later day communities varies from those of the early settlers in North America. Replacing the small free trade industries of hunting and fishing, mining communities are closely related to the expanding industrial growth of the cities, in that they rely upon very much the same type of labor and skills as their urban counterparts. For this reason, some degree of urbanity is essential to these new communities since, in order to compete with city-based industries, housing, amenities, and salary/wage scales must be adequately attractive.

In order to minimize the problems arising from the mobility of labor and labor turnover, mine management is finding that it must give more than cursory thought, not only to housing and amenities, but to the social and communal life of the mine work-force. Governments also have an important environmental part to play through the provision of roads, educational and communicative facilities, and the like.

It has been said that inadequate planning has been a feature of many of the isolated mining communities even in the recent past, and proposals for the future suggest that the essential aspects of community development which should perhaps receive closer attention include siting, planning, administration, housing policies, recreation, community institutions, and public relations.

It is essential to develop a full appreciation of the sociological off-the-job factors to be introduced into the concept of mining towns of the future. Employees should be encouraged to enter upon all phases of their social environment as full community participants, freed from any form of company political pressure, and should be encouraged to act and behave as citizens. Management and men both have a part to play in community affairs and, in a community sense, must each contribute to the other's overall participation.

In single enterprise communities industrial relations could well become, in effect, community relations because the company comes into contact with the miners themselves and with their wives and children as well. In the early stages, the company has often been called upon to play the combined role of employer, banker, chief taxpayer, home provider and local government, a role which has sometimes led to difficult social relations between company officials and "townspeople". Under such conditions, the company may have been impelled to assume a paternalistic attitude towards its employees and their dependents, in an effort to make the community "one happy family".

"Keeping the wives happy" is often a difficult organizational problem. Wives develop feelings of claustrophobia, notably in communities in the midst of or up against mountains, or surrounded by forests or the relatively barren Canadian shield. For personal contentment, wives enjoy the ability to shop, to have a "hair-do", to participate in church or recreational activities all of the year round, and to feel that their children too are in an adequate social environment. Some are confronted with the predicament of adolescent youth, who, growing into adulthood in an isolated community, are faced with a dilemma that the city youth does not encounter—anxiety regarding a future vocation, or merely the future (particularly in relation to daughters), education (particularly secondary and higher education), and so on. These are the problems of the miner and his family as a unit, giving rise to anxieties which may be carried on to the job. Companies are finding it beneficial to make every effort to assist family units to overcome these problems which, through their impact, could have adverse psychological and sociological effects upon company operations.

In the isolated mining communities, one sometimes hears the comment: "When you come home from the mine, the mine comes with you". This reflects the mental attitude of both the miner and his wife. It is probably more emphatic if the living quarters are within ear-shot of the company whistle or if the miner lives in a company-owned house. The whistle itself has been known to create problems through resentment because, in the single enterprise community, there is only one whistle—"his master's voice"! It should be a "buffer" by way of a [illegible] between the township site and the operations site to reduce such [illegible].

Strenuous efforts should be made [illegible] ing recreational facilities, community and company-supported, to cater for off-shift leisure periods. Shift work presents [illegible] cial problems in any case, but it could reduce accessibility to recreational facilities unless special arrangements are made. Governments have a vital interest in [illegible] mining communities, which, by creating well-being, constitute loci of further national development; it is important that up-to-the-minute news or the National Hockey League games can be enjoyed, not only in [illegible] and Montreal, but in the most isolated mining community.

The automobile straddles the distance between the isolated community and its [illegible] neighboring large centre, if highways are provided. Miners are able to relax at home the mine at reasonably frequent [illegible]. One gathers that it is the view of the owners of some of the newer isolated communities that, if properly used, the forests amongst the trees, rocks, water, and other natural features could be so developed as to encourage the company employee and his family to think of their community more as a resort than as a miniature city. If citizens could be persuaded to accept such a view of living in an isolated community, much could probably be done to improve the community environment, which impinges upon the day-to-day mining activities.

In Canada and Alaska, where the frontiers of mining are pushing further and further northwards, and where mining in the future will call for the solution of the problems of "arctic" mining, the upper echelons of management are now realizing the importance that these sociological and communal problems will have on the exploitation of this continent's mineral wealth. Feasibility studies of the future must embrace not only the technical and economic factors, but the human factors as well. Necessity will force the dove-tailing of these facets of organizational behavior. But necessity should not be the only impelling motivation and the mining industry as a whole should, under the favorable conditions of its expanding existence, appreciate the importance of these factors and their composite contribution to the operational environment.

Conclusion.

In this review, a number of topics, which a few years ago would not have been considered relevant to the mining environment, have been discussed: some of the topics would have been considered beyond the scope of the engineer and engineering management. It is possible that little new has been introduced into individual environmental facets, but the review will have served a useful purpose if it has brought the several facets together and demonstrated their interrelationships insofar as the total environment of our industry is concerned.

In the past, mining engineers have not been called upon to study closely the psychological and sociological problems of their own industry and even physiological aspects have not been as fully appreciated as the background to many of our physical environmental controls should demand. Today, we are realizing that they are important, not only in day-to-day policies of safety and accident prevention, but in routine processes of personnel control and personnel management.

The engineer is rapidly expanding his knowledge and his influence into these newer fields, because feasibility studies of new mining ventures recognize them as factors in the ultimate success of the enterprise. Educationally, the mining engineer must be trained to think in these broader terms. His is often the decision on problems that embrace, or are influenced by, other training and disciplines which impinge upon his own professional responsibilities and which are coming more and more into his orbit.

I am impressed by both the potential and the problems of the north, problems which lie within the sphere of responsibility of the management of single enterprise communities, of which the mining industry provides the principal examples. I consider that an understanding and fuller appreciation of these problems should be included in the present day training of mining engineers, upon whom will fall the future task of planning, and bringing into production, the mineral resources of this continent.

Even established managements may find it beneficial to recast their thinking and modify their approach to industrial problems that are constantly in a state of change as individuals and communities develop their self-expressions and modify their attitudes towards environmental conditions. In many of the older mines, it may perhaps be difficult to adjust fully to the changes and tempo, not only of newer technological development, but present day trends in social and personality adaptations. The management of newer mines can grasp the opportunity to analyze and benefit from the broader approaches. In our joint planning, as mining engineers concerned with the training for, and application of, our profession, all aspects of the miner and his environment must necessarily be considered.

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THE NEW FEDERAL SAFETY LEGISLATION AND YOUR OPERATIONS

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An interest in safety in all phases of industry, particularly the mining industry, is manifested in various forms of positive action to promote and improve safety and is being carried on by individual companies, mining associations, safety organizations, mineral trade associations, employee organizations, and by agencies of the State and Federal governments.

One method of positive action in the field of mine safety is the enactment of a law. This method does not always meet with unified agreement when the law provides for the entry of the Federal government into a field of activity, whether it is in mining activities or some other industrial activity. Some would prefer that each segment of an industry develop its own safety programs, adapted to its own peculiar conditions—in short, "self-policing". Others would prefer that authority to develop and administer safety codes, standards, or regulations be left at the state or local level. The position is taken by some that the activities of the Federal government should be confined to improving health and safety research, training, and the collection, compilation, and analysis of accident statistics. The Federal Metal and Nonmetallic Mine Safety Act is a composite of all those views, and there is room for all to operate concurrently.

The purpose of the Act is to promote health and safety in metal and nonmetallic mineral industries; or, expressed in a different manner, to reduce the accident rates and improve health and safety conditions in mining and milling operations.

Having expressed a purpose what does the Act do to accomplish it?

1. It establishes a Federal program of systematic inspection of those operations of each mine the products of which regularly enter commerce, or the operations of which affect commerce, and it requires the development, promulgation, and enforcement of health and safety standards. Thus, the Federal government is injected into the promotion of health and safety in metal and nonmetallic industries.

2. The Act provides for a modified joint Federal-State program of inspections where an agency of the state has adequate legal authority to enforce its own existing health and safety standards which in the judgment of the Secretary of the Interior are substantially as effective as the mandatory standards promulgated and adopted by the Secretary, and which provide for inspection at least annually of mines other than quarries and sand and gravel pits that are subject to the Act. This aspect of the law affords the opportunity for, and emphasis on, the development and administration of health and safety codes, standards, or regulations by the States. The State plan provisions of the Act will be discussed later in more detail.

3. The Federal government is further injected into the program of positive action in the area of health and safety research, training and the collection, compilation, and analysis of accident statistics. The Act provides that expanded programs should be developed for the education and training of employers and employees in the recognition, avoidance, and prevention of accidents and unsafe or unhealthful working conditions in the mines. The use of the term "expanded" programs is a recognition of what the Bureau of Mines has been doing for years with the cooperation of employers and employees. The Act further provides that operators of mines shall submit, at least annually and at such other times as the Secretary of the Interior deems necessary, reports of accidents, injuries, occupational diseases, and related data, and the information obtained from these reports shall be compiled, analyzed, and published, either in summary or detailed form. All the information and reports are to be published and released to any interested person and they shall be available at the mines for public inspection.

4. Where does "self-policing" fit into the picture? Standards may be developed and promulgated; statistics may be compiled

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