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NATIONAL SAFETY CONGRESS
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Volume 13

NATIONAL SAFETY CONGRESS

TRANSACTIONS

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NATIONAL SAFETY COUNCIL
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Citation for Distinguished Service to Safety to

JULIUS N. JACOBSEN, Safety Chairman,
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The judges were impressed with Brother Jacobsen's tenacious efforts on behalf of safety in his local union. The documented material vividly revealed the many extensive activities he promoted and participated in. It also showed the amount of time and energy he unselfishly put forth to promote safety.

The judges noted the many areas of activity in which he is engaged, including safety training, and the fact he was not deterred in achieving noteworthy goals. The Awards committee of the Labor Conference warmly commends him for his solid achievements.

OCCUPATIONAL HAZARDS—MAKING THE INVISIBLE VISIBLE

By RALPH NADER
Attorney, Author, Safety Critic, New York, N. Y.

The chief forms of domestic violence affecting American working men and women are motor vehicle crashes and occupational dangers and diseases. Taken together or singly, their toll in death and injury utterly dwarfs the violence incurred through street crimes. While the nation is properly concerned about street crime, it virtually ignores the far greater death, injury, and wage losses on farms, in mines, factories and open work areas such as construction sites. Consider one comparison out of many that could be detailed: all the riots in this country during the past three years in our cities have led to about 260 dead; each working day brings death to 55 workers, disabling injury to 8,500 workers and lesser injuries to 27,200 other laborers. Every year, 14,000 to 15,000 workers die, over half a million are disabled by occupational diseases, over two million are disabled by occupational accidents, and over seven million are injured. The toll is even greater than indicated by the above data because death through toxic exposure over time to chemicals or particulate matter is rarely recorded. The half million plus workers disabled from the effects of asbestos, beryllium, carbon monoxide, coal dust, cotton dust, cancer-causing chemicals, dyes, pesticides, radiation etc. must be taking terminal doses over time from some of these exposures. There is another reason why the above data must be considered understated—a reason which leads to the first of six realities which should be recognized publicly before significant progress can be made to reduce worker injury and disease:

1. Under-reporting by industrial firms of actual injuries and disease experienced by laborers has long been an endemic managerial disease. First, the definition of what constitutes an injury is decided by an industry-dominated body called the United States Standards Institute of America—a group of industries and industry technical societies. Second, companies go to considerable length to avoid reporting a lost time injury—not only to keep their insurance rates down but to preserve their place in safety competitions. For example, a worker in a Jones & Laughlin steel plant received a groin injury; he was taken off his usual job and placed in a chair where he sat doing nothing for two weeks. Any blue-collar man knows that such a practice is not unusual in numerous industries.

2. Plant physicians surrender to or are constrained by corporate dictates as to the exercise of their medical judgment and right to publication of cases in the medical literature. A recent case in point involved a Dr. John Zalinsky, a physician at the Brush Beryllium plant outside Cleveland, who had cases of workers suffering from beryllium poisoning and wanted to publish them in a

medical journal (without mentioning their names, of course). He was told if he did he would have to look for another job. The doctor had a bad heart and was concerned about looking for other employment. Before he could do anything, he died of a second heart attack.

Dr. Lorin E. Kerr of the United Mine Workers Welfare and Retirement Fund, an authority on coal workers' pneumoconiosis (or, as the coal dust disease is popularly called, "black lung"), has sharply denounced "the attitude and influence of employer-oriented physicians who avoid facing known facts about the ravages of coal dust in human lungs because to do otherwise would cost money. The impact of physician knowledge and attitudes is apparent in inaccurate or incomplete death certificates. These documents are essential for determining the existence of a dangerous dust requiring governmental action for control or eradication. Too often, no records mean no action. Physician denial or avoidance of known facts can also determine the publication of information. In 1956, the concern of some physicians about management attitudes effectively blocked the publication of a paper of mine on coal workers pneumoconiosis in the most widely circulated medical journal in the United States. One can only wonder how many times other medical information vital for the protection of the health of workers has not been published for the same reason. Physician attitudes also influence other groups such as company lawyers, state legislators, and officials who, all-told, are remarkably resistant to the elimination or control of coal dust because it would cost money."

Coal workers' black lung or pneumoconiosis affects at least 150,000 active and retired miners in advanced stages of lung destruction. Two thousand men die from this disease in Pennsylvania every year. What Dr. Kerr was referring to was a critical rupture in the recording and communicating of data by members of the medical profession.

3. State safety laws and regulations are weak, inspection is poor, and penalties rarely imposed. The states spend an average of 40 cents per worker per year on industrial safety. Some states such as Texas and Oklahoma have taken this down to two cents per worker per year. Of the 1,524 state inspectors, 697 inspect boilers, elevators and mines, leaving only 827 inspectors for general safety inspection, construction, safety promotion and education, health, and industrial hygiene, according to the Bureau of Labor Statistics. (There are almost twice as many fish and game wardens — about 3,000 — employed by the states to look out for wildlife.) Four states have no safety inspection staff in any area and 17 other states have 10 or less on their safety inspection staffs. More shocking is the fact that only three states have staffs specializing in the area of occupational health and industrial hygiene.

4. By and large, union leaders have been far too pliable when confronted by management's inaction or decisions regarding worker health and safety. Too often, health and safety conditions are treated as trade-offs for more tangible union gains in wages at the collective bargaining table. This has been the case, for example, with the United Mine Workers leadership, which finally is becoming slightly aroused over the plight of their workers but little dedicated to overturning coal management's modus operandi that treats coal miners as being less expensive than coal. Union leaders simply do not give health and safety a first rank priority; their lack of aggressive lobbying for the proposed Occupational Safety and Health Act of 1968 in Congress cannot be covered up by resolutions and resonant statements for the records. Labor leaders are wanted on the ramparts, not just on the record.

5. The Federal government has abdicated its responsibility to devote funds toward effective research programs and training programs for occupational health and safety. The Department of Health, Education, and Welfare (HEW) has had no sense of the importance of this problem, the need to develop preventive systems and competent medical and engineering personnel. HEW's advocacy has been weak and, if anything, the occupational health activity in the Department has been downgraded recently. The one area where HEW has received some consistent funding—$5 million since 1953—for research on the causes and prevention of coal workers' pneumoconiosis has had little to show for it, apart from a prevalence study completed three years ago. It is dismaying to note that not only does Western Europe spend twenty times the level on research in the coal dust disease area, but

control measures are years ahead of this country, which does not even have coal dust standards in force.

6. The workmen's compensation system in this country—its coverage, benefits, and deterrence—is creaking with obsolescence. A thorough inquiry is needed and serious thought should be given to uniformity. Not only are there irrational or politically inspired differences between states but some states are still mired in a value system of a bygone age. For example, coal miners' black lung disease is not considered work-related by the compensation laws of all states, except Pennsylvania (1965), Virginia (1968), and Alabama. Such human derelicts, spitting up coal dust, struggling for breath, afflicted with emphysema, massive fibrosis, or enlarged heart, are denied workmen's compensation in such states as West Virginia, Kentucky, Ohio, and Illinois. In Kentucky, according to the state's Department of Labor, about 1,400 out of 2,000 mines licensed to do business do not comply with the workmen's compensation law for other mine injuries apart from black lung. Yet, the present governor and his predecessor have not considered law and order to be applicable to coal operators.

Where does this leave the National Safety Council? Certainly, it does no service to truth and candor to hide the fact that the Council's industrial members and constituency take a strong interest in how far the Council goes in the occupational health and safety area. That interest, to use a mild word, resulted in the Council's being placed in a difficult position regarding the Occupational Safety and Health Act of 1968. Some observers believed that the Council retracted from a relatively positive position on the bill in February to a statement more in consonance with industry's preferences a few months later. For the Council, it is the same old dilemma of "to be or not to be" that has plagued its potential independence in other safety areas. If the Council is to be true to its potential in occupational health and safety, it cannot ignore at least some of the above-noted problems obstructing progress toward more humane working conditions.

LASER BEAM PRECAUTIONS

By WILLIAM McCULLOUGH
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Before we consider the hazards and precautions for the safe use of the laser beam, we should understand what it is. The name laser is an acronym for light amplification by stimulated emission of radiation. The original concept was invented by Dr. Townes in 1955. In 1958 Dr. Townes and Dr. Arthur Schawlou gave a paper on how to construct an optical maser. The name maser is an acronym for micro-wave amplification by stimulated emission of radiation. An optical maser is a laser.

In 1960 Dr. Theodore Maiman, a scientist then working with the Hughes Aircraft Company, gave the world's first demonstration of a laser beam. In 1964 Dr. Townes won the Nobel prize for his work on the theory of lasers.

The light that comes from a conventional light source radiates in all directions in waves of varying lengths that reinforce or cancel each other. Because it is non-directional and of varying wavelengths, it is said to be incoherent. Light from a laser beam travels in only one direction and is all at the same wavelength, so that it reinforces itself and is known as coherent light. Because it travels in one direction in straight lines, it is a very narrow beam.

To obtain a directional beam from an incoherent conventional source of light it must be focused, and even then it soon spreads it's beam again. Ordinary light sources are usually heat units such as incandescent lamps, arc lights, etc. In a neon tube the glass walls remain cool but the electrons activate the neon atoms within the glass tube and accelerate them to levels normally found at high temperatures. The atoms of the source material are brought to a continuous excited state and they fall back to normal by losing energy through heat and visible light.

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NATIONAL SAFETY CONGRESS
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MINING

NATIONAL SAFETY COUNCIL
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down the shaft to the other two levels, killing 52 men. It was then described as the worst mining disaster in U.S. history and to my knowledge, it is still so regarded.

Briefly, here are some of the facts: of the 52 killed, 34 lived within the limits of one small city. Forty were married. Three pairs of brothers and three father and son teams were among the victims. The oldest victim was 66; the youngest, 18. Survivors included 107 children under the age of 16—three men left seven children each. One man survived, climbing 800 feet in 10 minutes.

The elected county mine inspector was in the mine at the time and was one of the casualties. Only 10 bodies were recovered. The maximum workmen's compensation benefit at that time was $14 per week payable for a maximum of 300 weeks.

The operating company was generally regarded as one of the pioneers in mine safety. The state mining engineer said, "The mine had not been under suspicion as dangerous." The state geologist described mine conditions as excellent and said, "Every possible precaution had been taken."

All of the community's limited resources were mustered to alleviate the hardships—nurses and clergymen banded together to visit and comfort the survivors, and merchants helped with donations of food and clothing. The company—self-insured for workmen's compensation — voluntarily included the survivors of the mine inspector, who was not an employee, on their compensation payroll. The Red Cross withdrew from the scene, saying the situation was so well handled that anything they might do would be a duplication of effort.

The company was cleared of any negligence, and the U.S. Bureau of Mines report said, "From inspection and study, it is our judgment that the mine was operated according to the best mining practices and that all care possible was taken by the mining company to safeguard their employees and that the accident was due to causes that could not have been foreseen."

I am confident that in the intervening 40 years those of you who are experts in the field have developed new techniques that would make a recurrence of such a disaster highly unlikely, and that you will continue to dedicate yourselves to the prevention of accidents, thereby assuring continued "community stability."

A SUMMARY OF OCCUPATIONAL HEALTH ASPECTS IN MINING OPERATIONS

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Mining is one of man's most ancient occupations. It began when man first began to dig for rocks and metals to make tools and weapons. About 20,000 years ago man began to sink shafts and drive tunnels for flint used to make knives, axes, and arrow heads. The Egyptians used copper for metal utensils, weapons, and ornaments over 15,000 years ago. By 4,000 B.C., copper was in general use throughout Europe. North American Indians had learned to hammer copper utensils, but they did not learn how to smelt copper. Copper and tin occur together around Cornwall, England; they were smelted together to produce bronze for the first time about 2,000 B.C. Bronze daggers and swords dating from this period have been recovered from ancient tombs.

Prehistoric man showed the effects of his occupational exposure to flint. He undoubtedly developed silicosis from flint-knapping—one of the oldest of industries. Egyptian mummies have been found with anthracosis and pleural adhesions. The stone cutters for the pyramids must have suffered from severe exposure to silica.

Miners have already been regarded as a breed apart. Living and social conditions described by the early historians were appalling. The ancient miners were almost always slaves, condemned criminals, prisoners

of war, or forced labor. The coal mines in Britain were developed in the twelfth century. Many lives were lost from accidents, black damp, fires, and explosion. In the 16th and 17th centuries the coal mines were greatly expanded with the industrial revolution. The industrial revolution brought rapid changes and was followed by awakened social concern about working conditions. Women and young children were employed in mines.

One of the earliest writers on the health aspects of mining was Georgius Agricola, who published his *De Re Metallica* in 1556. Agricola discussed in detail the mining, smelting, and refining of gold and silver. He recommended ventilation with fresh air for mine workings. He also recommended the use of masks to protect against mine dusts.

Mining operations, because of their diversity, present a wide variety of occupational exposures, some of which can result in ill health and disability. I hope in this presentation to touch on many of these exposures, with more particular reference to the mining industry in Ontario.

To some degree, underground work is similar to work done within confined spaces. For this reason, greater attention must be paid to toxic substances encountered underground. The air in mines is more likely to be contaminated than the air in factories. With abnormal conditions, e.g., fires, severe conditions are imposed. Adequate ventilation and control of air is most important in mines.

Pneumoconiosis-Producing Dusts

The pneumoconioses still constitute what is perhaps the most difficult as well as the most severe and costly of the occupational health problems which the mining industry has to face.

Coal Miners' Pneumoconiosis. Coal dust itself has always been considered to be a basically inert dust. In coal mining operations, however, it may be inhaled in large amount. The amount of free silica present in the airborne dust is usually quite small. Two main types of pneumoconiosis are described: simple pneumoconiosis and progressive massive fibrosis (PMF). The former is frequently associated with focal emphysema, whereas in PMF large solid masses of scar tissue are found in the lung. Tuberculosis is implicated in the majority of cases.

Ontario has no coal mining and I have no first hand experience on this subject. A superficial look, however, at the prevalence of coal miners' pneumoconiosis indicates the magnitude of the problem around the world wherever coal is mined. In the United States, a survey of 2,549 Appalachian bituminous coal miners covering the period 1963-1965 disclosed 9.8 per cent with definite x-ray evidence of pneumoconiosis. These miners had spent an average of 29.7 years underground. Considerable publicity has been given to compensation for coal miners' disability in Pennsylvania.

The prevalence of pneumoconiosis in coal miners from different countries is demonstrated in an I.L.O. report. I have adapted information from this publication in the Table below.

TABLE I

Prevalence of Coal Miners' Pneumoconiosis

Country	*Year*	*Number of Coal Miners*	*Per Cent Miners with Pneumoconiosis*
Australia, N.S.W.	1948	—	12.5
	1960–63	11,526	3.5
Austria	1962	3,487	(8)*
Czechoslovakia	1960	150,000	13.3
France	1962	196,099	12.4
Germany	1961	317,707**	(2,668)*
India	1960	—	18.8
United Kingdom	1962	440,900**	(1,656)*

*New cases reported that year

**Underground miners only

Silicosis. The inhalation and retention of excessive amounts of free silica (mainly quartz) gives rise to nodular formation of fibrous tissue in the lungs. This fibrosis increases and impairs the function of the lung. Silicotics have increased susceptibility to tuberculosis, and this is responsible for the major disability.

In Ontario gold mines, the quartz content runs up to 40 per cent, and in uranium mines up to 70 per cent. In nickel mines, the quartz content is quite low. In all, there are about 17,000 underground miners in Ontario. The number of clinically disabled cases of silicosis among these runs from five to ten each year. About 400 actively employed miners show x-ray evidence of silicosis without any disability—a prevalence of about 2.3 per cent.

Of 14,076 actively employed metal miners in the United States examined between 1958-1961, 3.3 per cent showed definite evidence of pneumoconiosis.

Asbestosis. Asbestos is a fibrous silicate. This form of pneumoconiosis is manifested by a diffuse interstitial fibrosis. Gas diffusion through the alveolar wall is impaired. Asbestos is mined extensively in Quebec; very little is found in Ontario. Cases of asbestosis in Ontario have resulted from its use; e.g., insulators. (Some talc is mined in Ontario, and a few cases of talcosis have been reported from this exposure.)

Dust Measurement. Maximum retention of dust particles in the alveoli of the lung occurs with particles of one to two microns in particle size. There is little retention of particles less than 0.02 micron or over five microns in size. The limit of the resolving power of a very good optical microscope is about 0.2 microns—more generally, the lower limit is fixed at 0.5 to 1.0 micron. There is general agreement that particles in the range of 0.5 to 5.0 microns are important from the point of view of inhalation into and retention in the lung.

In Ontario, dust sampling in mines is done with the konimeter, in most of the United States it is done with the impinger, and in Britain the thermal precipitator is mainly used. In Ontario, konimeter counts of less than 300 particles per c.c. are considered good; counts of 300 to 500 are fair, and counts greater than 500 are considered bad; all mines are sampled twice yearly. As matters stand at present, no evaluation or comparison of the dust-measuring methods for mine air (and consequently no definition of a maximum concentration which is not to be exceeded) has any significance unless the type of equipment, the method of sampling, and the nature of the dust are precisely known.

In mine dust, determination of the free silica (quartz) content of the airborne dust is important. With coal dust, it is customary to incinerate the sample to determine the amount of ash and also the quartz content of the ash.

The development of pneumoconiosis in a miner depends first and foremost on the cumulative effect of dust exposure. As the exposure increases the incidence increases, and the disease becomes more severe. In some cases, it is apparent that the total mass of coal dust (or other inert dust) is more important than its content of ash.

In order to standardize methods for assessing the pneumoconiosis risk, a method of gravimetric sampling of the respirable dust, with analysis of the collected dust, seems indispensable. There is much movement in this general direction. The threshold limit value for quartz, for example, is now shown on a gravimetric basis in the 1968 *Notice of Intended Changes* published by the American Conference of Governmental Industrial Hygienists.

A standard for respirable coal dust is needed. The earlier British recommendation for "approved conditions" is noted below:

Location	*Dust Particles per c.c.*
Anthracite collieries	Less than 650 between 1 and 5 microns
Other collieries	Less than 850 between 1 and 5 microns
Stone drifts and hard facings in all collieries	Less than 450 between ½ and 5 microns

Further studies have taken place in Britain with gravimetric size selective sampling, and the results of this study will be of interest.

The USSR maximum permissible concentration for coal dust of less than five micron particle size are also shown.

Coal Dust	*Maximum Permissible Concentration mg/m³*
Coal, more than 10% quartz	2
Coal, less than 10% quartz	4
Coal, no quartz	10

Toxic Dusts

Miners exposed to mercury, manganese, or soluble lead dusts may develop systemic poisoning. Lead sulphide ores present no real hazard in mining—only in smelting. Miners exposed to manganese dust in both Chile and Cuba have been reported to develop central nervous system effects similar to Parkinsonism. No mercury, manganese, or lead mines are found in Ontario. It is perhaps worthwhile to mention that manganese steel is commonly used underground in jaw crushers. A welder in Ontario using an oxy-acetylene torch to cut manganese steel underground developed kidney damage which was attributed to the manganese fumes. Ventilation in the work area was inadequate.

Much of the free world's nickel is mined in Ontario. Dust in nickel mines has not produced occupational health problems apart from occasional cases of dermatitis. Increased risk of nasal sinus cancer and lung cancer has been reported in workers involved in sintering and calcining nickel sulfides. This has not occurred in the mining operations.

Increased risk of lung cancer has also been demonstrated in the refining of a cobalt ore containing arsenic. These workers also showed increased incidence of chronic pulmonary fibrotic disease. This exposure is still under study. Arsenical dermatitis is common in handling this material and a few cases involving perforation of the nasal septum from arsenic have occurred.

Noxious Gases

The word noxious comes from the Latin word injurious. To the industrial hygienist, a noxious substance is one which produces adverse effects on the worker from annoyance or discomfort to illness or death.

Oxygen Lack. Oxygen is the most important constituent for human life. Man can live only a few minutes without oxygen—his reserve of stored oxygen in the lungs, blood and tissues is sufficient to last for only four to five minutes once he is deprived of oxygen.

Oxygen lack can occur in mines in different ways—by dilution with simple asphyxiants seeping out of rock strata, by absorption of oxygen into rock strata (this occurs mostly in coal mines), or by consumption in chemical or biological reaction. Oxygen lack can be very insidious in its effects, because it causes impairment of judgment. Therefore, persons in an oxygen-deficient atmosphere may be aware of some difficulty, but they are unable to take the appropriate safe action.

The concentration of oxygen in mine air should be maintained above 18 per cent. When the concentration falls below 16 per cent, symptoms of oxygen lack begin to appear. At levels of six per cent or less, collapse can occur very quickly.

Nitrogen, helium, argon, and hydrogen act as simple asphyxiants by excluding oxygen. Some other gases may be broadly considered to be in this category even though they have other physiological actions. These include carbon dioxide, methane, and ethane. The older term "black damp" refers to a mixture of carbon dioxide and nitrogen.

Carbon Dioxide. This gas acts as a respiratory stimulant. Air normally contains about 300 ppm. Workers would not be likely to notice any effect on breathing until the concentration exceeds two per cent in air. Since it causes deeper and faster breathing, it may enhance the effect of any toxic gas present with it, for example, carbon monoxide.

Methane. This gas occurs most commonly in coal mines. It is occasionally encountered in other mines—iron ore, salt, etc. It is primarily a fire and explosion hazard rather than a health hazard, but can act as an asphyxiant.

Carbon Monoxide. Carbon monoxide is not a normal constituent of the air. It is produced by combustion sources—fire, explosion, or the internal combustion engine. It is produced by blasting agents. Concentrations of 400 to 500 ppm in air may be tolerated for a short time; exposures of 1,500 to 2,000 ppm are dangerous in a short time. I do not feel there is sufficient evidence to accept the concept of chronic carbon monoxide poisoning from repeated exposures underground.

Ammonia. Ammonia is occasionally encountered underground. It provides adequate warning of its presence, because of its irritating action.

Sulfur Dioxide. This is produced by the reduction of sulfide ores. Blasting in some types of sulfide ores may produce temporary high concentrations. It acts primarily as an irritant of the upper respiratory tract,

but severe exposure may result in bronchitis and occasionally edema of the lungs. It has been suggested that continued exposure to low concentrations of sulfur dioxide could result in chronic respiratory disease; e.g., chronic bronchitis with or without emphysema. At the present time, a study is underway in a group of smelter workers exposed to sulfur dioxide in Ontario. Their respiratory illness experience will be compared to other groups in the same company not exposed to this gas.

Oxides of Nitrogen (Nitrous Fumes). Of these, nitrogen dioxide (NO_2) is of special importance. It is produced in diesel exhaust and from blasting agents used underground. The ventilation requirement for diesel engines used underground is determined by the nitrogen dioxide produced (and the disagreeable odor of aldehyde).

This is one of the most insidious of all gases. It may be inhaled in lethal concentrations without marked discomfort at the time of exposure. Later, it produces a delayed pulmonary edema.

Air sampling after blasting underground shows peak concentrations occur two to six minutes after the blast, and significant concentrations may remain for about 15 minutes after the blast. Commonly, levels of 200 ppm are produced, but values up to 800 ppm have been reported after blasting.

Adequate ventilation must be provided to remove nitrogen dioxide and other gases produced by underground blasting. After blasting, there is nearly always mixed exposure to carbon monoxide and oxides of nitrogen. For this reason, any worker affected by blasting fumes with headache, dizziness, or collapse should always be considered to have suffered a significant exposure to oxides of nitrogen as well. Restriction of activities for 24 hours is most important in these cases.

It has been recommended that 75 cfm per horsepower be provided for the control of diesels used underground.

Arsine. Arsine is formed when nascent hydrogen is produced in the presence of arsenic. Acid treatment of arsenical ores may give rise to arsine production. Exposure to arsine results in destruction of red blood cells with anemia. This anemia may develop within a few hours in acute exposures, and in severe cases the anemia is extreme; death may result in two to six days in these severe cases. Chronic changes from arsine exposure may also occur.

Hydrogen Sulfide. Hydrogen sulfide is produced chiefly from the decomposition of organic matter. It may occur in mines where sulfide ores are found. It is soluble in water or oil and it may flow for some distance from its place of origin to escape at some unexpected place. Hydrogen sulfide has a characteristic odor at low concentrations. Its odor cannot be relied upon, however, to give adequate warning of its presence, because in lethal concentrations this gas rapidly paralyzes the sense of smell. Such concentrations also affect the respiratory center in the brain resulting in failure of respiration.

Radioactivity

Radium, a naturally occurring radioactive isotope, is distributed in small amounts in the earth's crust. The radioactive disintegration of radium results in radon-222 and radon daughters. The air in underground workings contains some radon from seepage of the gas into mine workings. In most nonuranium mines, the concentration of radon does not present any significant exposure; one notable exception is the fluorspar mine in St. Lawrence, Newfoundland.

In uranium mines the radon concentration in the mine air is much higher than in other mines. Studies of uranium miners in the United States have revealed a significant increase in the incidence of lung cancer. The increased incidence is related to the concentration of radon and its short-lived daughters and to the length of time of exposure. It has been estimated that 30 to 50 per cent of deaths in Schneeburg and Joachimsthal miners was from lung cancer as a result of radon exposure.

The hazard from radon daughters is measured in Working Levels (WL). One WL is defined as that combination of radon daughters in one liter of air that will result in an ultimate emission of 1.3×10^5 *MeV* of potential alpha-energy.

In unventilated underground mines, the concentration of radon daughters may vary from a fraction of a WL to several thousand WL. Presumably, some degree of risk exists at all working levels but the maximum increase of lung cancer occurs when the cumulative exposure exceeds 1,000 working level months (1,000 WLM), *and* when the miners

are moderate to heavy smokers, *and* when they have worked in the mines 10 years or more.

The simplest control measure is to ventilate the mine with fresh outside air. Another method of control is to limit the miner's time in areas high in radon and daughter products. In all areas where radon is being emanated, the ventilation rate should provide one complete air change every four minutes unless radon daughters have been shown to be low. (This rate of ventilation is very high for a mining operation and I do not think it would be feasible for large scale uranium operations.) Each pair of men mining in the ore should be provided with 1,000 cfm of fresh air discharged from an outlet not more than 30 feet from the working face. On drifts, the airflow needed should be calculated to provide a velocity of 30 ft./min. These recommendations on ventilation are all taken from *Public Health Service Publication No. 494.*

Exposure to thoron and thoron daughters has also been raised in connection with uranium mining. This is currently under study in Ontario.

Noise

Noise in mining operations deserves special comment in its own right. Drilling and underground crushing almost always create excessive noise levels requiring a good hearing conservation program, involving preemployment and periodic audiograms plus the wearing of hearing protection for all workers in high noise areas.

Heat

As mines go deeper, the rock temperature increases by about ½° to 1°F for each 100 feet. When the area is opened up, the heat radiates into the air space. At 8,000 feet, Northern Ontario mines reach a temperature of about 90° to 100°F, with high humidity. Control of humidity at these temperatures presents problems.

In relatively shallow mines, from 300 to 600 feet down, cold can present a problem in Northern Ontario. Heating of fresh mine air is done to take care of these upper levels.

Lighting

Because of the long distances involved and the large unused area underground in hard rock mines, lighting is not extensively used in mines. Miners often work in semi-dark locations. Such levels of illumination likely contribute to accidents underground. No reports of nystagmus, common in British coal miners in Wales, have appeared in Ontario. Miner's nystagmus is related to poor levels of illumination, but there appears to be an emotional overlay.

Vibration

In Ontario, Raynaud's phenomenon of occupational origin (white hand) has occurred in large numbers of aluminum foundry chippers using pneumatic guns. Occasionally, cases are encountered in steel chipping and auto assembly work, but these are quite uncommon. I am not aware of any cases occurring in Ontario hard rock miners using pneumatic drills. It was my impression that the vibration frequency and the amplitude was not in the same range as that of the aluminum chipping guns. It is of interest, however, to note that cases have been reported in uranium miners in Saskatchewan who used a smaller "jack-leg" drill. An important factor in these cases is the cold ambient temperature in the area where these men worked.

Explosives

Some occupational health aspects involving explosives have been touched on in discussing the various gases which might be encountered in mining. Careless handling and storage of dynamite containing nitroglycerin may result in headaches (powder headaches) and cardiovascular stress. Nitroglycerin enters the body by inhalation or skin contact. It dilates capillary blood vessels, resulting in low blood pressure. Two workers employed in the manufacture of explosives died of cardiovascular stress while away from the job.

More recently, mixtures of ammonium nitrate and diesel fuel (AN/FO) have come into use in underground blasting. Trouble has been experienced in Ontario with improper mixing of this material in the past. This has been controlled. Occasionally, there are isolated cases of dermatitis. From time to time, questions are raised concerning oil mist exposure, particularly in filling overhead holes.

From the occupational health point of view, AN/FO mixture does not present any greater hazard than the use of conventional explosives.

In Ontario, a number of deaths have oc-

curred in workers entering blast areas too soon after the explosion. In some cases, the workers died of acute carbon monoxide poisoning; in others, mild carbon monoxide effects were noted, followed by a fatal pulmonary edema from inhalation of oxides of nitrogen.

Synthetic Resins

Various synthetic resins have been introduced into mining applications for special purposes; e.g., grouting and sealing, and rock bolting.

Epoxy and polyester resins are used in rock bolting. The use of epoxy resins may result in cases of respiratory irritation and dermatitis from the hardeners used. Dermatitis is occasionally encountered with the polyester used.

Polyurethane has been used in mines as a seal. These contain isocyanates (MDI or TDI). Of these, MDI is less volatile and less likely to give trouble. Both of these isocyanates, however, may give rise to bronchial irritation or allergic bronchitis with asthmatic-like symptoms. Workers applying polyurethane foam and those in the general area should wear adequate respiratory protection. An air line respirator is recommended. Workers 150 feet away or more do not require respiratory protection, provided the air flow from the area of spraying is not too excessive.

Acrylamide has been used for grouting. Acrylamide is quite toxic, and cases of dermatitis and peripheral neuritis have been reported with this material.

Conclusions

A wide variety of substances and other agents may be encountered in mining operations. It is important that supervisors and the workers be familiar with the possible adverse health effects of their occupational exposures. To help eliminate or minimize these health effects, the following preventive and other measures are especially noted:

1. Education and supervision of the worker.
2. Handling methods to minimize dust.
3. Ventilation. Local ventilation should be used where possible at the point where contaminants are generated. General ventilation with provision of fresh air to maintain the concentration of contaminants below their threshold limit values. Ventilation doors and fans must not be interfered with.
4. Rescue and First Aid Training.
5. Regular Monitoring. Periodic dust sampling should be carried out. The threshold limit values should be used as guides to arrive at reasonable control measures. Radioactivity levels should be carried out regularly, not only for uranium mines, but others as well.
6. Medical Supervision
   (a) Dust Exposure. Pre-employment and periodic examination, including chest x-rays, should be done on all miners.
   (b) Noise Exposure. An adequate audiometric testing program should be done.
   (c) Toxic Dusts (e.g., lead). A regular program of examination and biological monitoring should be carried out.
   (d) Radiation Exposure.

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