Bureau of Mines
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LOSS OF LIFE AMONG WEARERS OF OXYGEN BREATHING APPARATUS

(REVISION OF I. C. 7279)

BY ALEXANDER E. MORROW

United States Department of the Interior — 1959

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UNITED STATES DEPARTMENT OF THE INTERIOR
Fred A. Seaton, Secretary
BUREAU OF MINES
Marling J. Ankeny, Director

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CONTENTS

	Page
Summary	1
Conclusions	1
Introduction	2
Acknowledgments	3
Circumstances leading to loss of life	4
Otho Graves	4
Henry Bucham	4
E. A. Sutton	5
Joseph E. Evans	5
John Farrell	6
William McColligan	8
Edward Evans	8
James Laird and B. Poyser	9
Gomer Phillips	9
Thomas Hendrickson	10
Lewis M. Jones	11
Walter Kerr	12
Samuel T. McMahon and Bryce Warren	12
David Murphy	14
William Taylor, Robert Kennedy, and Loren Whitler	15
James S. Cunningham	15
Henry DeWinter, Hugh Hughes, and James Hudson	16
Philip White	17
Thomas Ritson	18
Albert Gilmore	19
George Wilson	20
Frank Burns, Roy Rushton, and William Heagy	20
Rush D. Hiller	21
Andrew Wolfgang	22
Reese Phillips and Gray Lacey	22
Arthur Kaemmerer	23
The three periods	24
Lessons learned	27

TABLE

1. Lives lost while oxygen breathing apparatus was being worn	26

LOSS OF LIFE AMONG WEARERS OF OXYGEN BREATHING APPARATUS[1]

(Revision of I. C. 7279)

by

Alexander E. Morrow[2]

SUMMARY

Oxygen breathing apparatus for use in mines was introduced to the United States in 1907. Despite their intended purpose of safeguarding lives, the apparatus led to the deaths of many men because of inherent or developed defects in the equipment, lack of training, physical shortcomings of wearers, and improper procedures.

The Bureau of Mines pioneered in research and training to curb loss of life among users of such apparatus and promoted development of safer equipment and procedures. As a consequence, deaths have been far less frequent.

In 1944 the Bureau issued Information Circular 7279, Loss of Life Among Wearers of Oxygen Breathing Apparatus. That publication listed the case histories of 26 deaths that had occurred since the introduction of such equipment to American mining. The author, the late G. W. Grove,[3] asserted that further loss of life could be avoided if good equipment were used, teams were properly trained, and the basic principles of safe procedure were followed.

This publication is a sequel to I.C. 7279 and contains information on eight deaths among wearers of oxygen breathing apparatus that were overlooked in the original compilation. It also describes the single death that occurred since I.C. 7279 was published.

CONCLUSIONS

The forecast made 15 years ago by Mr. Grove that deaths among users of oxygen breathing apparatus can be avoided has become a reality, as reflected by the almost unbelievable safety record since attained.

1/ Work on manuscript completed July 1959.

2/ Assistant to District Supervisor, Health and Safety District B, Bureau of Mines, Pittsburgh, Pa.

3/ Deceased 1950 while Chief, Accident Prevention and Health Division, Region VIII, Bureau of Mines, Pittsburgh, Pa.

The safe use of oxygen breathing apparatus depends on carefully selected, well-trained men wearing apparatus of approved design that are in good condition; a proper organization under the direction of a competent man or men; and strict adherence to sound, safe procedure. If these essential requirements are followed rigidly, few, if any, lives will be lost as the result of wearing such apparatus.

That oxygen breathing apparatus can be worn with safety needs no further proof. The continuing record of the last 19 years gives eloquent testimony to this fact; however, if the lessons of past failures are forgotten and the basic principles outlined on pages 27 and 28 are neglected, serious consequences are almost certain.

INTRODUCTION

The wearing of self-contained oxygen breathing apparatus, although relatively safe if proper precautions are taken, is dangerous if defective apparatus is worn, if men with inadequate training, experience, and physical ability are used, and if improper procedure is followed.

The self-contained oxygen breathing apparatus is the only breathing equipment designed to withstand for as long as 2 hours either poisonous mine gases, regardless of concentration, or atmosphere containing little or no oxygen. In recent years both oxygen and compressed-air self-contained breathing equipment have been approved by the Bureau of Mines for shorter periods of time. These are described in I.C. 7808, Auxiliary and Supplemental Mine Rescue Equipment.

Self-contained breathing apparatus were introduced in this country in 1907, and since then, they have been used widely in conducting rescue and recovery work after mine fires and explosions and in some other work, All oxygen breathing apparatus used in the United States before 1918 were imported from Europe, and although this equipment provided safer and more rapid means of conducting recovery work after mine disasters, there were many mechanical deficiencies in the apparatus that caused the death of some of the wearers. This led to the research and experimental work by the Bureau of Mines that resulted in the development and manufacture of more reliable and more efficient types of apparatus in this country.

Little or no oxygen breathing apparatus have been imported since 1918, as the types designed, developed, and made in the United States are in all respects equal and in many ways superior to foreign makes.

Before 1912 little attention was paid to instructing and training men in the construction, testing, use, and care of oxygen breathing apparatus, and still less consideration was given to proper procedure in conducting rescue and recovery work. It was not unusual for one, two, three, or four men to put on apparatus and make, or attempt to make, explorations ahead of fresh air after mine disasters. Often these men had little or no previous training in wearing the apparatus other than a few oral instructions, and little or no thought was given to the possibility of mechanical failure of the equipment or what might be done for the relief and rescue of apparatus wearers should

mechanical failure develop in a poisonous, noxious, or oxygen-deficient atmosphere. Moreover, no limit was placed on the distance apparatus wearers might travel ahead of fresh air, and no effort was made to determine the physical condition of the men before they donned the apparatus.

Under such conditions it is not strange that men collapsed and lost their lives while wearing oxygen breathing apparatus, but rather it is surprising that a greater loss of life did not occur.

Investigation by the Bureau of Mines of the death of several men who were wearing oxygen breathing apparatus resulted in the adoption in 1921 of Mine Rescue Standards. These standards, published as Technical Paper 334 in 1923, contained requirements for physical condition of apparatus wearers and the procedure to be followed in rescue and recovery operations. The Bureau also has issued handbooks describing in detail the construction, testing, wearing, etc., of oxygen apparatus; the first was published in 1923, the second was issued in 1941, and the third, Mine Rescue Apparatus and Auxiliary Equipment, will be published soon. No doubt the first two handbooks contributed materially to the safe use of breathing apparatus. In fact, a decided improvement was evident immediately following the publication of the first handbook.

Since April 1944, when the original manuscript by Mr. Grove regarding men who lost their lives while wearing breathing apparatus was published, nine additional cases have been found. All but one occurred during the 35-year period covered in the original publication. Since February 1950 Bureau records on coal-mine fatalities are complete, and they list only one case since October 1940 where a life was lost while a person was wearing a breathing apparatus. This case probably should not be included, as the victim was not a mining man. He was wearing unapproved equipment in an abandoned mine and was violating other major safety rules. From October 1940 to July 1959, a period of nearly 19 years, we do not know of a single death among wearers of permissible oxygen breathing apparatus in coal mines of this country.

We know of several cases where lives were lost while wearing oxygen breathing apparatus in foreign countries, and a few cases in this country where firemen lost their lives while fighting fires in buildings; these cases are not included in this publication, as we are covering only those fatal accidents that occurred in mines of this country. One exception was made in the case of James S. Cunningham, a Bureau of Mines man, who lost his life in a gasoline tank. This case was also in the original publication.

In a record such as this omissions and errors are likely to occur. Others whose names are not included may have lost their lives while wearing oxygen breathing apparatus in mines. In some instances people who were present gave different versions of the same accident. One account states that four men lost their lives, but the names of only three were given.

ACKNOWLEDGMENTS

Since the acknowledgment in the former paper by Mr. Grove has historical interest, it is quoted as follows:

The assistance of M. J. Ankeny, mining engineer of the Safety Division of the Bureau of Mines, in abstracting material from Bureau of Mines and State reports and in preparing a considerable amount of the material contained in this publication is gratefully acknowledged.

Acknowledgment is made also to S. H. Ash, mining engineer, Bureau of Mines, Washington, D. C., for information and suggestions regarding the accident in the slope of the Pacific Coast Coal Co.; to L. L. Naus, mining engineer, Division of Safety, Bureau of Mines, Denver, Colo., for obtaining information relative to the occurrence in the Wanamie Colliery; and to Peter McLinden, inspector at large, West Virginia Department of Mines, Fairmont, W. Va., for information in connection with the accident on November 13, 1917, in the Jamison No. 7 mine, Barrackville, W. Va.

Additional acknowledgment is made to those whose help was received either from former letters on file or because of efforts to find additional facts for use in this revision. They include: C. A. Herbert, recently retired Supervising Engineer, Health and Safety District E, Vincennes, Ind.; George H. Deike, Chairman of the Board, Mine Safety Appliances Company, Pittsburgh, Pa.; and H. B. Humphrey, Mining Health and Safety Engineer, Washington, D. C., retired.

CIRCUMSTANCES LEADING TO LOSS OF LIFE

The Bureau of Mines has information showing that from 1908 to 1940, inclusive, 33 men lost their lives while wearing oxygen breathing apparatus in the coal mines of this country. Four of the 33 were Bureau of Mines employees. Two additional fatal accidents are recorded herein; one deals with a Bureau of Mines employee who lost his life in a gasoline tank, and the other happened in 1955, the only such fatal accident on record since 1940.

The names of persons who lost their lives while wearing oxygen breathing apparatus, followed by a brief account of such facts as are known concerning these fatal accidents, are listed in chronological order as follows:

Otho Graves

On December 24, 1908, Otho Graves, age 23, employed by the Zeigler Coal Company No. 1 mine, Zeigler, Ill., lost his life fighting a mine fire while wearing a Draeger helmet. He was overcome by heat and lost consciousness. The other members of the party tried to bring him out but were unable to carry him all the way. A rescue party was quickly formed, but when they got Graves to the surface he was dead.

Henry Bucham

On January 29, 1909, Henry Bucham, also 23 years old and an employee of the Zeigler Coal Company No. 1 mine, Zeigler, Ill., breathed poisonous gases while wearing a Draeger helmet. He died February 9, 1909. He reportedly thought his helmet was too tight and in his attempt to loosen it breathed the poisonous gases.

The cases of Graves and Bucham are the earliest on record, but some very desirable details are missing. The information on these two accidents was obtained from the files of the Illinois Department of Hines and Minerals.

E. A. Sutton

On February 9, 1911, E. A. Sutton, assistant superintendent of the Cokedale mine of the Carbon Coal & Coke Co., Carbondale, Colo., lost his life while wearing a Draeger helmet-type oxygen breathing apparatus after an explosion in this mine in which 17 men were killed.

This company was one of the first in Colorado to purchase oxygen breathing apparatus, but only three apparatus were purchased and available at the time of the explosion. Sutton had worn the apparatus on only two previous occasions, for 1/2-hour periods, and therefore was not thoroughly familiar with its operation.

Sutton and a superintendent from a neighboring mine each put on an apparatus and left the third at the fresh-air base in reserve. When they had traveled a considerable distance from the fresh-air base, his companion, who was traveling about 150 feet behind Mr. Sutton, saw him struggle with his apparatus and suddenly fall. The companion immediately returned to fresh air for help.

After considerable delay, two workmen volunteered to go after Sutton without the aid of respiratory protection; when they reached a point within about 100 yards of where he was lying, one collapsed and the other returned to fresh air. Thirty minutes thereafter additional apparatus crews arrived and recovered the bodies of Sutton and the workman. They were treated with a pulmotor for more than an hour, but neither could be revived. Unfortunately, the names of the two men who went after Sutton were not obtained, although one of them lost his life.

Examination of Sutton's apparatus revealed that one of the potash cartridges had not been connected at the bottom. This permitted the injector to pull in outside air, which presumably contained carbon monoxide.

Joseph E. Evans

On April 7, 1911, Joseph E. Evans, foreman miner of Bureau of Mines rescue car No. 1, lost his life while wearing a Draeger self-contained oxygen breathing apparatus. Evans' death occurred during an exploration trip in the Pancoast colliery of the Price-Pancoast Coal Co., Throop, Pa., after a mine fire in which 72 other persons were killed.

Evans and his crew of three men, consisting of a Bureau of Mines employee, an ex-employee of the Bureau of Mines, and another man, had proceeded about 500 feet ahead of fresh air when Evans experienced some difficulty with his apparatus. After leaving one of the men with Evans and advising them to return to fresh air, the other two men proceeded on the exploration trip, returning to the fresh-air base by a different route. Following a brief rest,

Evans and his companion proceeded about 80 feet toward the fresh-air base when Evans fell. His companion, after first examining the apparatus to see whether it was functioning properly, went to look for the other two members of the party. Failing to find them, he proceeded to the fresh-air base and reported that Evans was down. Shortly thereafter, the other two men of the party reached the fresh-air base and, upon learning that Evans had collapsed, went to where he had fallen. After adjusting Evans' apparatus, they proceeded to the fresh-air base to obtain additional help. Later they returned with help and brought him to the fresh-air base on a stretcher. The application of artificial respiration and the use of a pulmotor failed to revive him.

No defects were detected in the apparatus.

John Farrell

On January 19, 1912, George H. Deike, mining engineer, and James T. Reynolds, first-aid miner, were taking training in oxygen breathing apparatus in the smoke room of the Bureau of Hines Rescue Station on the old Arsenal Grounds, Pittsburgh, Pa. This was the headquarters of the Bureau of Mines at that time.

John Farrell was the foreman miner in charge of the station and was supervising the instruction of the two men in the smoke room. During the 2-hour training period Farrell came to the door of the smoke room and instructed the two men in training to come out, as word had been received that a sealed fire area was to be opened in the mine of the Pittsburgh and Eastern Coal Co., at Cherry Valley, Pa.

Farrell assembled four Draeger self-contained oxygen breathing apparatus in standard trunks, and the three men were joined by Frank Seibert, who was one of the chemists of the Bureau station. He was taken along in order to obtain samples of the air inside the sealed area and to act as a member of the apparatus crew.

The trunks were opened in the engine room at the mine, and each of the crew was assigned one of the breathing apparatus. When the apparatus assigned to Deike was put on it was found that the backrest had been omitted, and therefore it could not be worn because of the protruding lugs that held the backrest in place. Farrell, who was in charge of the party, said that they would go into the mine with the three apparatus and that he and Seibert, the chemist, would enter the sealed area and Seibert would take the desired samples. The plan, as he outlined it, was for the two of them to enter the fire area and, after taking their samples, to return to the fresh-air base, at which time the apparatus that Seibert was wearing would be turned over to Deike to wear; Farrell, with Reynolds and Deike, then would enter the area for the purpose of making a full inspection of the sealed section.

When the apparatus crew arrived at the sealed area, they found that none of the seals had been broken, and it took several hours to break a hole through one of the seals large enough for the men wearing apparatus to enter. Farrell took an active part in handling a sledge hammer in helping to open the

seal. When a large opening had been made, Farrell and Seibert, wearing Draeger helmet-type apparatus, entered through the opening and walked about 215 feet to find the source of the fire. Within 5 minutes after entering, Frank Seibert indicated that he was having difficulty with his apparatus and wished to return to fresh air. Farrell directed him to do so, indicating that he would follow. When the distressed man reached the outside of the stopping he discovered that Farrell had not followed him as he expected. Shortly after he reached the outside of the stopping he heard three raps on the trolley wire within the sealed area, indicating that Farrell might be in distress. James Reynolds then entered the sealed area, wearing a Draeger mouthpiece-type apparatus, in an effort to find Farrell. Reynolds returned in about 5 minutes, exhausted, and collapsed at the opening of the stopping. He was pulled through and was revived by artificial respiration. After Reynolds was taken outside, he reported that he had found Farrell at the face of a room, lying on his back with his helmet off; but in trying to get him out through a narrow space between the rib and a car his (Reynolds's) nose clip was dislodged. After inhaling some of the bad air, he was compelled to return to the fresh air without Farrell.

George H. Deike, wearing the helmet-type apparatus previously used by Seibert, made four attempts from two different openings in the stoppings to find Farrell, but failed each time because Farrell's body was behind a car in one of the rooms. Deike returned to fresh air after his final trip, completely exhausted.

Later that night J. W. Paul and John T. Ryan, mining engineers from the Bureau of Mines, arrived from Pittsburgh. With the two stoppings already opened, the ventilation was restored in the fire area, and the body of Farrell was recovered. He was behind a car in a chute near the face of one of the rooms. The oxygen supply of Farrell's apparatus was completely exhausted, but the pneumatic face cushion of the helmet, although not on his face, was still inflated. A bruise on his forehead indicated that he had fallen and dislodged his helmet. It is also possible that in trying to get around the mine car his helmet was pulled off, and before he could get untangled he dropped.

Subsequent tests of the apparatus worn by Farrell revealed that the apparatus was defective to the extent that outside air could get into it. Whether this defect occurred before or after the apparatus was taken into the mine or at the time of the accident could not be determined. The Pittsburgh Station of the Bureau tested this apparatus and found the defect to be at the bottom of the cooler. The cooler was on the suction side of the Draeger oxygen breathing apparatus. An opening about 1-1/4 inches long was found in the seam on the bottom of the cooler, indicating that irrespirable gases in the fire area would bring difficulty to the wearer in less than 10 minutes.

Tests of the apparatus worn by Seibert, and later by Deike, showed that irrespirable gases entered at the bottom of the cooler because the saliva-release cap of the cooler, instead of being closed tight by four full turns, was cross-threaded at less than one full turn; this fact permitted the gases to be sucked into the apparatus in such amounts as to affect the breathing of the wearer in approximately 27 minutes. A similar condition existed in the suction zone of the apparatus worn by Reynolds.

The defects in design of the Draeger apparatus, revealed by this and other accidents, led to the development of the positive-pressure Gibbs apparatus, the forerunner of the present-day McCaa apparatus.

William McColligan

On April 23, 1913, William McColligan, a member of a rescue crew of the Pittsburgh Coal Co., died while making an exploration trip ahead of fresh air after an explosion in the Cincinnati mine at Courtney, Pa., in which 97 men were killed.

McColligan and his crew of five men were equipped with Draeger helmet-type apparatus, which had been carried into the mine by a reserve crew so that the apparatus men would be in good condition for advance work. After exploring a series of entries and starting back toward the fresh-air base, McColligan collapsed. The other crew members tried to drag him to fresh air, but two of them went down in the attempt; however, they were able to get up and stumble out to the fresh-air base. Several men from the fresh-air base tried to reach McColligan without the use of apparatus but were unable to do so, and his body was not recovered until after fresh air was directed into the place where he collapsed. Two physicians then worked on him for over an hour, using artificial respiration, electric batteries, and a pulmotor, without response.

The apparatus worn by McColligan was examined by two representatives of the Bureau of Mines, who found that the flexible tube inserted in the thimble, directly over the injector, had been pulled out of its socket, allowing the toxic mine atmosphere to enter the apparatus.

Edward Evans

On September 30, 1913, Edward Evans, an employee of the Bureau of Mines, died during mine rescue maneuvers at the No. 1 mine of The Union Pacific Coal Co., Rock Springs, Wyo. Evans, wearing a mouthpiece-type Draeger oxygen breathing apparatus, was making a training trip underground under oxygen with a complete crew when he collapsed. He was promptly brought to the surface, and an attempt was made to resuscitate him with a pulmotor. A doctor, who arrived shortly thereafter, stated that heart action had ceased. The atmosphere in which the maneuvers were being conducted was irrespirable because of blackdamp.

Despite the fact that Evans apparently was in robust health and had passed several physical examinations in connection with his mine rescue work before his death, an autopsy revealed defective heart and kidney conditions. Reports concerning Evans' death indicate that he had spent his entire life in low-altitude sections of the United States and that his work at Rock Springs, where the altitude exceeds 6,000 feet, may have been a contributory cause of his collapse and death. Although the reports indicated that Evans passed the required physical examination in Pennsylvania before wearing breathing apparatus, there was nothing to show that he had been given a physical examination before wearing apparatus in high altitudes. A physical examination given to Evans before he entered the mine might have revealed the defective heart

condition, So far as could be determined, the apparatus worn by Evans was not defective.

At the time of this accident the authorities were beginning to realize that there was much need for improving breathing apparatus. Tests conducted previously on the Draeger apparatus in England indicated that the regenerator of the apparatus could not absorb all the carbon dioxide exhaled by the wearer while performing strenuous work.

James Laird and B. Poyser

On October 22, 1913, James Laird and B. Poyser, members of a rescue crew of five men of the Stag Canon Fuel Co., lost their lives while on an exploration trip in the No. 2 mine of the same company at Dawson, N. Mex., following an explosion that killed 256 men. The crew, equipped with Draeger helmet-type apparatus, had been instructed that if they came to heavy falls they should not attempt to go over them. When a heavy fall was encountered, the leader of the crew, in accordance with his instructions, told the others that they should return to the fresh-air base. However, two members of the crew disregarded these instructions and pushed forward over the fall; they were followed by the others, and eventually the crew reached the face of the entries, about 2,000 feet from the fresh-air base. Soon after examining the faces of the entries and before starting back toward the fresh-air base, Laird collapsed. Poyser, in attempting to revive Laird, also collapsed. The leader of the crew stayed with the men, attempting to revive them, while the remaining two crew members returned to the fresh-air base. When the crew leader realized that his oxygen supply was getting low, he also returned to the fresh-air base. The accident disorganized the rescue personnel so badly that it was not possible to assemble a crew of volunteers to recover the bodies until the next morning.

Gomer Phillips

On May 25, 1915, Gomer Phillips, an instructor in charge of first aid and mine rescue for the Cambria Steel Co., lost his life 400 feet beyond the fresh-air base while on an exploration trip after an explosion in the No. 1 mine of the Smokeless Coal Co., Johnstown, Pa., in which eight persons were killed.

A crew, consisting of Phillips and three other mine rescue men of the same company, wearing Fleuss oxygen breathing apparatus, left the fresh-air base to make an exploration trip of about 1,400 feet. After advancing about 500 feet, Phillips complained that he did not feel well, but he was persuaded by a member of the crew to continue on the exploration. After traveling some distance, Phillips suddenly turned, broke away from the crew, and started running toward the fresh-air base. He ran about 30 feet and fell forward on his face. The other three men of the crew followed him, picked him up, and carried him about 60 feet, but stopped because of exhaustion, and two of them fell down. The remaining crew member succeeded in reaching the fresh-air base and reported that the other three men were down. Two other men, without apparatus, attempted to reach Phillips and the other two members of the rescue

crew, but this effort failed. Canvas brattices were then erected in the cross-cuts, and fresh air was directed toward the point where the men had collapsed. One of the men was met crawling toward the fresh-air base on his hands and knees. Phillips and his companion were found where they had fallen. They were carried or dragged about 350 feet to the fresh-air base. On reaching the fresh-air base artificial respiration was applied, and Phillips' companion was revived in about half an hour. However, continued artificial respiration and the use of a pulmotor for over an hour failed to revive Phillips. Careful examination of the equipment worn by these men failed to reveal any defects.

Thomas Hendrickson[4/]

On September 17, 1915, Thomas Hendrickson, a foreman of the International Exploration Co., lost his life while wearing a Draeger 2-hour oxygen breathing apparatus during an exploration in the Alta-Quincy tunnel, near Salt Lake City, Utah, leased by the Albion Mining Co.

According to newspaper accounts, the drift in which Hendrickson died became filled with carbon dioxide gas. A day or two before the accident the owners of the Albion mine sent to the Salt Lake City Fire Department to obtain oxygen breathing apparatus, and a captain of the department took two apparatus to the mine.

On arrival at the mine, Hendrickson (who claimed he had wide experience in wearing oxygen breathing apparatus), with a Draeger helmet-type apparatus, and the fire-department captain (who had no experience in wearing apparatus), with a Draeger mouthpiece-type apparatus, accompanied by a group of men, entered the tunnel. After traveling some distance, their flame lights went out and they retreated a short distance to where the lights would bum. The two men with apparatus then turned on the oxygen and proceeded with the exploration, leaving the other men without apparatus at that point.

After traveling about 2,000 feet, Hendrickson experienced difficulty with his apparatus, and after retreating about 200 feet, assisted by the other man, he collapsed. In falling, he pulled the mouthpiece and nose clip off the face of his companion, who then tried to break a compressed-air line to get air. Becoming exhausted, the fire-department captain was compelled to leave Hendrickson and retreat toward fresh air.

The captain was later rescued, while crawling on his hands and knees toward the fresh-air base, by men who had been left at the fresh-air base. Several other men at the fresh-air base previously had been overcome in an effort to reach him. After recovering, he made four attempts to break the compressed-air line, thus permitting the recovery of Hendrickson's body.

4/ Hendrickson's first name also appears as James and Jack in newspaper clippings, either of which may be correct instead of Thomas.

Lewis M. Jones

On October 20, 1916, Lewis M. Jones, a mining engineer of the Bureau of Mines in charge of rescue and recovery work for the Bureau, lost his life while wearing a Fleuss oxygen breathing apparatus on an exploration trip following an explosion in the No. 7 mine of the Jamison Coal & Coke Co., Barrackville, W. Va., in which 10 men were killed.

The exploration party, consisting of Jones as the rear man, three other Bureau of Mines apparatus men, and one local apparatus man, left the fresh-air base pulling a lifeline and carrying six 100-foot coils of clothesline to be attached to the end of the lifeline when it was extended to its full 1,000 feet. Another Bureau of Mines man and a local man, both equipped with oxygen breathing apparatus, and a third man not so equipped were left as a reserve crew at the fresh-air base. When the full length of the lifeline was paid out, the coils of clothesline were attached, one after another, until all were fastened together. The party then proceeded 1,000 feet or more beyond the end of the lifeline, a total of about 3,000 feet, and had almost reached their objective when they stopped for a short rest and to read their apparatus gages.

The trip up to this point had been made at a moderate pace, under good conditions of travel, with ample height and few falls. Travel was resumed, and after traveling a short distance, the man next to Jones noticed that he was not following the crew. This man immediately returned to Jones and found him leaning against the rib. Jones' knees then gave way and he started to fall. The crew member placed his hand on Jones' chest, pushed him against the rib to prevent him from falling, and examined his apparatus. Finding the main oxygen valve of Jones' apparatus closed, the crew member opened it and the bypass valve. On receiving the fresh oxygen Jones seemed to rally for a short time but soon collapsed. He then was placed on a stretcher by the rest of the crew, who had joined Jones and his companion, and it was determined that his mouthpiece and nose clip were in place. He was breathing heavily, but the apparatus apparently was working properly. The party then started out; after carrying Jones about 1,300 feet outby, one of the men became exhausted, and they had to stop. When they stopped, they gave Jones extra oxygen through the bypass. Two of the party started for the fresh-air base for help, leaving the two others with Jones. About 20 minutes later the two men, who were with Jones, decided that they too would be forced to leave him because their oxygen was getting low, and it was feared that the other two men might not have reached the fresh-air base. When these men left, Jones was still breathing heavily.

Both parties reached the fresh-air base safely, but considerable time was consumed in organizing a relief crew to get Jones. Finally three men wearing breathing apparatus, who were met by a fourth man on his way out, went in and brought out Jones. In their haste to get Jones to fresh air, they did not take the time to determine whether he was still breathing. At the fresh-air base artificial respiration was started immediately, and oxygen was administered by a resuscitator. Meanwhile, a doctor arrived and upon examining Jones failed to detect any heart action. When the oxygen supply of the resuscitator was exhausted, a lung motor was used for a while without results. The doctor

finally decided that Jones was dead and discouraged further efforts at resuscitation.

A period of 2 hours and 20 minutes had elapsed between the time the original crew left the fresh-air base and the time Jones' body was brought back to the fresh-air base.

Subsequent examination and the wearing of the apparatus worn by Jones disclosed no defects, except for a small crack or break in the base of the rubber mouthpiece where it joined the outer flap; however, this may have been caused after the apparatus was removed from Jones, as, according to some of the crew members, little attention was paid to it, and possibly several men walked on the mouthpiece during the efforts to revive him.

The reason why the main oxygen valve on Jones' apparatus should be found closed by the man who first reached him can readily be understood when it is considered that the gage valve on a Fleuss apparatus could and often was placed directly over the main closing valve when the reducing valve was being attached to the oxygen bottle. Because the wearers of the apparatus were instructed to keep the gage valve closed except when actually reading the gage, this sometimes resulted in the wearer closing the main oxygen-supply valve instead of the gage valve. When this occurred, the oxygen in the apparatus would be consumed in a short time, and the wearer, in his efforts to obtain air, might draw outside air containing carbon monoxide into the apparatus. This may have happened to Jones, and the carbon monoxide drawn into the apparatus caused his death.

Walter Kerr

On May 6, 1917, Walter Kerr, a member of a mine rescue team of The Colorado Fuel and Iron Corp., died wearing a Draeger 2-hour oxygen breathing apparatus, while helping to recover bodies, after an explosion in the Hastings mine of the Victor-American Fuel Co., Hastings, Colo., in which 121 men were killed.

Kerr, while assisting other members of an apparatus crew in carrying a body, suddenly left his crew and later was found dead in a crosscut at the face of an entry. Detailed information concerning this occurrence is not available; however, while there apparently was some idea that the apparatus worn by Kerr might have been defective, an autopsy disclosed that he had a defective heart, that overexertion caused heart failure under the strain of wearing apparatus, and that a defective heart condition existed previous to his death.

This case again emphasizes the need for a careful physical examination before a man wears an apparatus under actual mine conditions.

Samuel T. McMahon and Bryce Warren

On November 13, 1917, Samuel T. McMahon and Bryce Warren lost their lives while wearing Fleuss oxygen breathing apparatus in a sealed fire area in the No. 7 mine of the Jamison Coal & Coke Co., Barrackville, W. Va.

An explosion occurred in this mine on October 19, 1916. The explosion resulted in a serious fire that required the sealing of the north section of the mine. (Lewis M. Jones, an employee of the Bureau of Hines, lost his life during an exploration trip after the explosion.) About a month after the fire was sealed in the north section of the mine, where an apparatus crew was making an exploration in the fire area, a local gas explosion occurred. The apparatus crew and about 35 other men, who were cleaning up the south section, immediately went to the surface. A few minutes after the men had reached the surface, a terrific explosion occurred, following which the mine was again sealed.

The services of McMahon, who at the time of the initial explosion was employed as district mine inspector by the West Virginia Department of Mines, were obtained to direct recovery operations. The work was begun about January 27, 1917, and to guard against the entrance of air into the sealed area, air locks were used during the recovery work. The air locks were erected about 900 feet apart, and on the day of the accident McMahon, Warren, and two other men wearing apparatus had been building stoppings to seal off openings in a 900-foot section. A lifeline was not being used, and no reserve crew was at the fresh-air base. About 3:00 p.m. one of the crew stated that he was feeling bad, and McMahon sent him and another man to the fresh-air base outside the air lock, stating that he and Warren would follow soon. At this time all the apparatus contained about a 40-minute oxygen supply. After waiting about 45 minutes and hearing nothing from McMahon and Warren, the two men at the fresh-air base became alarmed. They entered the air lock and upon opening the door of the second stopping of the air lock they saw a light on the floor about 200 feet inby. The two men, under oxygen, proceeded to the light and found McMahon unconscious, nose clip removed, hand on bypass valve, and oxygen supply exhausted. The two men then, instead of attempting to rescue McMahon, proceeded to the surface to obtain assistance; as a result, McMahon's body was not recovered until about 5:00 p.m., or about 1 hour and 20 minutes after being discovered. Artificial respiration was used for some time, but McMahon could not be revived.

Warren's body was recovered about 9:45 p.m., or approximately 6 hours after being found, a few feet inby the stopping at the extreme end of the 900-foot section of the main air lock. His nose clip was off and the bypass valve of the apparatus was open. This stopping was equipped with a slide door and there were indications that McMahon had endeavored to assist Warren through this door. Evidently McMahon and Warren had explored some distance inby the stopping at the end of the air lock and ran out of oxygen before they could reach fresh air. The apparatus worn by McMahon and Warren had, so far as known, operated perfectly for about 1 hour and 20 minutes before the accident or up to the time the two other men left them. Both sets of apparatus were tested after the accident, and no defects were found. It is believed that Warren's oxygen supply became prematurely exhausted owing to excessive use of the bypass valve and that McMahon, in attempting to assist Warren, also used oxygen faster than he expected, thereby depleting his supply. However, in view of the limited oxygen supply at the time that the two other men left them, they should not have attempted an exploration and should have returned to fresh air.

David Murphy

On February 26, 1918, David Murphy, an experienced mine rescue volunteer from Dawson, N. Mex., died while wearing a Fleuss mouthpiece-type oxygen breathing apparatus during an exploration trip in the Government mine of the Carthage Fuel Co., Carthage, N. Mex.

The crew of five men who made the exploration trip was supervised by a representative of the Bureau of Mines. He lost his own life the following year while wearing oxygen breathing apparatus in a gasoline tank.

All members of the crew were given careful physical examinations by the physician attached to the Bureau of Mines rescue car, but Murphy was not familiar with the operation of the Fleuss apparatus, having been trained previously in the use of Draeger apparatus.

Before entering the slope, the portal of which was the fresh-air base, the team captain inspected all apparatus and saw that each machine was working properly. He also stopped at intervals on the way down the slope to ask whether each man was all right. After reaching their objective, about 600 feet from the portal, it was decided to return to the surface. About 300 feet from the portal, Murphy indicated that he was in distress. The team captain adjusted his mouthpiece and nose clip, gave him more oxygen with the bypass, and placed him on a stretcher. At this time another member of the team exhibited signs of distress and sat down on the floor. Two of the team members carried him some distance up the slope, but were unable to carry him out because of exhaustion, and they decided to go to the surface for help.

Meanwhile, the team captain remained with Murphy, adjusted his mouthpiece, tied it firmly in place, adjusted his nose clip, and turned him over on his face. He then attempted to carry him but was unable to do so. The attempt to carry Murphy exhausted the team captain to the extent that he was able to reach the surface only with extreme difficulty.

When the team captain reached the surface, and it was determined that two men were still in the slope, it was decided to remove the seal from the mouth of the slope and drop a trip to where the men were lying on the roadway. After reconditioning the apparatus, the trip, containing the team captain and three others, was lowered on the slope to where the first man was down. It was noticed that his apparatus was still functioning and that he had 30 minutes of oxygen remaining. He was put in the car and taken to the surface immediately. The trip was then lowered to where Murphy was lying. It was observed that he had turned over on his back, that the mouthpiece was partly out of his mouth, and that his nose clip was off. Fifteen minutes oxygen supply was still in the oxygen cylinder. Murphy was placed in the trip and brought out at once. Stimulants, artificial respiration, and oxygen inhalations were given, but he failed to revive. Breathing was restored to his companion in about 15 minutes, and he regained consciousness in about an hour.

A lifeline was used by this crew in making the exploration, but a reserve crew was not maintained at the fresh-air base. The apparatus worn by Murphy

and his companion were worn again 2 days later under actual working conditions, and no difficulties were experienced. It is reported that the team captain had some difficulty in controlling Murphy and his companion while they were on the exploration trip, and that they talked to each other incessantly before the accident. It is surmised that each of them inhaled carbon monoxide around their mouthpieces while talking.

William Taylor, Robert Kennedy, and Loren Whitler

On June 29, 1918, William Taylor, age 37; Robert Kennedy, age 44; and Loren Whitler, age 34, lost their lives in the No. 8 mine, O'Gara Coal Co., Eldorado, Ill. A fire in this mine had been sealed about 2 weeks. For no apparent reason Superintendent William Taylor decided to open a seal and do some exploring on a Sunday night. Evidently, four men entered the sealed area. One member of the team was wearing a leaky apparatus, and the other team members struggled with him to keep him from removing his apparatus. They gave him a shot of oxygen and continued the investigation instead of returning to fresh air. Shortly thereafter the same man again had trouble, lost his head, and in the struggle with the other team members, three lost their lives, including Mr. Taylor, the team captain. One man succeeded in getting back to fresh air.

James S. Cunningham

On August 25, 1919, James S. Cunningham, foreman miner of Bureau of Mines rescue car No. 2, died while wearing a Salvus 1/2-hour apparatus in a gasoline storage tank of the Sinclair Oil & Refining Co., Trinidad, Colo.

The gasoline tank had a capacity of 12,000 gallons and was about 18 feet high. There was a manhole at the top and a steel ladder on the inside, leading from the manhole to the bottom of the tank, The gasoline in the tank at the time of the accident was about 7 inches deep.

Cunningham tested and checked the apparatus carefully on the rescue car and proceeded directly to the place where he had volunteered to enter the gasoline tank to make a pipe connection. He entered the tank through the manhole, went down the ladder to the bottom, and then returned to the top to make sure his apparatus was functioning properly. Two employees of the oil company stayed at the manhole at the top of the tank. It is reported that a suggestion was made that a lifeline be used, but since it was not immediately available, Cunningham decided to enter the tank without it. After determining that his apparatus was functioning properly, he went down the ladder the second time and found the place where the connection was to be made. Immediately thereafter, and before starting to work, he exhibited signs of confusion or distress, then fell over into the gasoline, lying with his head submerged in the gasoline. His body was later recovered with a grappling hook.

The apparatus was sent to the Pittsburgh Experiment Station of the Bureau of Mines for inspection and testing where it was found that the rubber lining of the breathing bag had deteriorated causing the sides to stick together. The inside rubber was found to be gummy, and the rubber lining on the outside

of the fabric had been almost completely dissolved. Tests also were conducted on a similar apparatus, a duplicate in every way of the one Cunningham used, by subjecting it to gasoline in both vapor and liquid forms. The conclusion from the tests was as follows: "The experiments show that gasoline and also gasoline vapor in higher concentrations can penetrate the thin rubberized bags such as have been used on the 1/2-hour oxygen breathing apparatus....."[11]

This accident led to the development of heavy rubberized breathing bags for oxygen apparatus that are now used on some of the modern mine rescue equipment. Subsequent tests on heavy bags revealed that high concentrations of gasoline vapors will in time penetrate them. The Bureau, therefore, recommends that the heaviest-type breathing bags should not be used in gasoline vapors longer than 2 hours, after which the bag should be discarded or thoroughly soaked and washed with water and aired out before reuse. It is recommended also that when necessary to enter a place containing gasoline vapors while wearing an oxygen breathing apparatus, a rope or safety belt should be provided and that the apparatus man or men should be watched closely so that they can be withdrawn immediately in case of distress.

Henry DeWinter, Hugh Hughes, and James Hudson

On July 10, 1920, Henry DeWinter, Hugh Hughes, and James Hudson lost their lives while wearing oxygen breathing apparatus in an abandoned slope of the Black Diamond No. 2 mine of the Pacific Coast Coal Co., Black Diamond, Wash. Hughes and DeWinter, wearing Draeger apparatus, were members of the Black Diamond mine rescue team which had gone down the slope to measure the height of the water in the slope as part of their mine rescue training practice. Hudson, wearing Gibbs apparatus, lost his life while assisting with the recovery of the bodies of Hughes and DeWinter.

The crew left the slope portal, which was the fresh-air base, without a reserve crew present but with a man at the portal to pay out the lifeline. The dip of the first 500 feet of the slope was about 25° and the remainder was 35°. The crew descended about 200 feet when the flame of the safety lamp which they were carrying was almost extinguished by blackdamp. They retreated a short distance, hung the lamp on a timber, and descended to the water, which was about 1,400 feet from the portal. After reaching the water, the crew members took a short rest, read their gages, and then started to return. They had proceeded a short distance when DeWinter collapsed. The team captain opened the bypass of DeWinter's machine, but there was no flow of oxygen. The four remaining members of the crew had carried him 30 feet, when Hughes collapsed. Realizing that it would be impossible to carry both men up the slope, the other three members of the crew decided to go to the surface for help. One of the men reached the surface in good condition, another collapsed when he reached the fresh air, and the third collapsed before he reached the portal and had to be assisted by the man that had been left at the fresh-air base.

A call was sent out for assistance, which was received by a Bureau of Hines employee who had just finished training a team at Burnett, a town 18 miles away. Taking four members of the Burnett team with him, the Bureau man drove to the mine immediately and organized a crew to enter the slope and a

crew to stay in reserve at the portal. The advance crew entered the slope and brought out the body of Hughes. Hudson and four other men, wearing apparatus, descended the slope to recover DeWinter's body. This crew had brought DeWinter's body a short distance when one of their members was found to be in distress, complaining of not getting enough oxygen, and later he went to the surface. It is generally supposed that in using the bypass valve he had turned off the main bottle valve (perhaps a condition similar to that described previously in the case of Lewis M. Jones). When this man found that his apparatus was again working properly, he started to rush up the slope, deserting the crew. On his trip out, he was met by another rescue crew coming down the slope. Two members of this crew assisted him until he was within 100 feet of the fresh-air base, when he collapsed. Men at the fresh-air base took him to the surface, where he was revived. He had worn a Bureau of Mines Fleuss apparatus, and it is believed that in his rush to get outside the oxygen supplied by the reducing valve was insufficient, causing him to gasp and inhale some of the mine atmosphere.

Soon after this man left the crew, Hudson became distressed. He was assisted a short distance by four other crew members, but finding it impossible to carry him they left one man with him and went for assistance. Soon thereafter the relief crew arrived and tied a rope around his body, The crew at the fresh-air base pulled him to the surface while the rescue crew guided his body. No reason is given for Hudson's collapse other than excitement or fright. It is known that when he collapsed his apparatus was apparently working perfectly and was adjusted properly. His apparatus became somewhat deranged while he was being dragged out of the mine, and he probably breathed some of the mine air. He was given artificial respiration for 1 hour and 27 minutes without results. Hudson had been wearing a Gibbs apparatus, which was tested later and found to be in perfect working condition; moreover, the same apparatus was worn again that same day, and no trouble was experienced with it.

When Hudson was brought out of the mine, it was believed that DeWinter was dead, and since the rescue crews were exhausted a second call was sent out for additional help. Rescue teams from Carbonado, Hyde, Bayne, and New Castle, Wash., responded. These apparatus men, in groups of three, were stationed at 200-foot intervals on the slope. DeWinter's body was lashed to a sled, which was pulled with a rope by men at the fresh-air base. The crew that lashed DeWinter's body to the sled guided it the first 200 feet, and then the next crew took over for the next 200 feet, and so on until the body reached the surface. Approximately 12 hours had elapsed between the time DeWinter entered the slope and the time his body reached the surface.

Philip White

On July 29, 1920, Philip White, district superintendent, age 41, lost his life while attempting to explore a part of No. 18 mine, By-Products Coal Corporation, West Frankfort, Ill., which had been sealed because of fire.

According to the information in our files, Mr. White was not satisfied with the progress being made, and, after a hearty Sunday dinner, he entered

the mine, borrowed the helmet of one of the men, took the lifeline, and ran ahead alone over several falls and collapsed. Reportedly, he became sick and vomited into his mouthpiece, thus rendering his apparatus inoperative.

Thomas Ritson

On the morning of September 2, 1921, a party composed of three men appointed by the Illinois State director of the Department of Mines and Minerals, the superintendent of the State rescue station at Harrisburg, Ill., and officials of the mine investigated an explosion that had occurred in the Harco mine, Harrisburg Collieries Company, on August 31, 1921. During this investigation, a crew composed of Frank Patterson, superintendent of the Harrisburg rescue station, William Lacy, safety inspector for the coal company, and three other men, Davis, Kilgore, and Ritson, all wearing Fleuss apparatus, explored the 9th and 10th and the 11th and 12th north entries for possible fires. During the exploration in the 11th north entry, Davis complained of distress. The team was immediately halted, and Davis' apparatus was examined and appeared to be functioning properly, but as he still complained of distress the team was ordered to retreat to the fresh-air base. At this time Ritson complained of being in distress, and Mr. Lacy examined Ritson's apparatus but could find nothing wrong with it. The gage showed 45 atmospheres of oxygen. Lacy then adjusted the man's nose clip and mouthpiece and filled the breathing bag with oxygen. Davis still complained of distress and was ordered to proceed to the fresh-air base alone. Patterson, Lacy, and Kilgore, carrying Ritson, followed toward the fresh-air base and had progressed from the No. 17 to the No. 13 room when Kilgore also complained of distress and was ordered by Patterson to proceed alone to the fresh-air base. Patterson and Lacy then continued carrying Ritson alone and got as far as No. 11 room, by which time they were both completely exhausted. As Ritson was a large, heavy man and the roadway very rough from falls of rock, walking was extremely difficult. As their own oxygen supply by this time was down to 15 minutes and they had reached the limit of their strength, they felt obliged to leave Ritson and proceed to the fresh-air base. Before leaving him they again adjusted his mouthpiece and nose clip and filled his breathing bag with oxygen.

As soon as Lacy and Patterson reached the fresh-air base, the other members of the party proceeded at once to carry the fresh air up the 11th and 12th north entries, and were able to reach Ritson's body in about half an hour. When found, his apparatus was still in working order, but his nose clip was off. Lacy and Patterson stated that Ritson's teeth were in very bad shape, and, in addition, he had a short, heavy, bristly mustache. It was the opinion of these men that the combination of the bad teeth and mustache made it difficult for Ritson to hold his mouthpiece tightly in his mouth and therefore had been breathing in a small amount of outside atmosphere, which was undoubtedly highly charged with carbon monoxide. His collapse and death, it is reasonable to assume, were due to this cause, since the apparatus worn by Ritson and those worn by Kilgore and Davis were examined and found to be working properly.

Albert Gilmore

On December 31, 1921, Albert Gilmore, a section foreman, lost his life in the No. 1 mine of the Ellsworth Collieries Co., Ellsworth, Pa., while wearing a Gibbs 2-hour oxygen breathing apparatus following a local mine explosion.

The apparatus crew, of which Gilmore was the leader, had been exploring two crosscuts ahead of the ventilation as the air was being advanced in the recovery of the mine. One of the five oxygen breathing apparatus belonging to the crew had been damaged in transportation, and another developed a leak while in service, leaving only three sets of apparatus available for use. The work was being conducted by sending the three available apparatus men ahead in such a formation that one man would stay far enough in the rear to be out of danger, with the thought that he could render assistance if the two men ahead encountered any trouble. A lifeline was not used, and there was no reserve crew at the fresh-air base. After four advance examinations had been made in this way, the crew started on a trip, but this time all three went together. Instead of advancing about 200 feet they traveled about 600 feet ahead of the fresh-air base when Gilmore collapsed. About 10 minutes after the crew left the fresh-air base one of the members came running back and collapsed upon his arrival at fresh air. His apparatus was taken off and recharged, but it was found that the apparatus was damaged so that it could not be used. The other member of the crew ran down the return airway and reached fresh air by coming through one of the canvas stoppings. His apparatus was also in such condition that it could not be used. The atmosphere ahead was so filled with afterdamp that it was impossible to reach Gilmore without respiratory protection. Therefore, it was decided to advance the air to where Gilmore had fallen. Owing to the distance supplies had to be carried, 2 hours were consumed in reaching the body of Gilmore. He was given artificial respiration and oxygen inhalations for 2-1/2 hours in the presence of a physician but failed to respond.

When he started the trip about 95 atmospheres of oxygen was in his apparatus, and oxygen was in the apparatus when his body was recovered.

It is reported that in addition to the exploration work done by Gilmore, while wearing apparatus, he had at various times during the night gone ahead of the fresh air without protection, endeavoring to expedite the recovery work, and he may have been near the point of exhaustion when he started on the trip in which he collapsed. Moreover, in traveling about 600 feet ahead of the air he disregarded the instructions given him at the fresh-air base.

The apparatus Gilmore wore was examined by a Bureau of Mines employee several days later and was found to be in good condition with the following exception: A large amount of leakage was found in the mouthpiece at the point where the metal flange is inserted in the rubber part. The rubber part had been placed upside down on the metal flange, and full dependence was placed on shellac to hold the metal and rubber pieces together to form an air-tight connection. The shellac had broken so that the connection was not air-tight. The recommended procedure for attaching the rubber mouthpiece to the metal flange is to apply shellac to the metal flange, insert it in the rubber

mouthpiece, wrap the connection with wire, and apply adhesive tape over the wire.

The atmosphere in which Gilmore died was deficient in oxygen and contained a high percentage of carbon monoxide. It is reported that immediately before he collapsed he turned his head and motioned to the other two crew members to come ahead. When he turned his head and not his body either the inhalation or exhalation tube would tend to draw on the side of the metal part of the mouthpiece and cause the loose rubber part to slip in such a way as to leave an opening through which the wearer could take a full inhalation of the deadly outside atmosphere. It is thought that the inhalation, which Gilmore took as he turned his head, was contaminated enough (in his presumably weakened condition) to cause his immediate collapse.

George Wilson

George Wilson, 34 years of age and foreman of the Standard Fuel Company No. 2 mine at Standardville, lost his life on March 9, 1924, while attempting to rescue some of the 171 men who were killed in the disaster in the Utah Fuel Company's Castlegate No. 2 mine, Castlegate, Utah. Gibbs apparatus were used by both teams mentioned herein.

Mr. Wilson, formerly captain of the Hiawatha mine rescue team, made three trips into the Castlegate mine with this team before he went in with the Standardville team. Reportedly, one or more of the Standardville team members got into difficulty and became panicky. In trying to alleviate the trouble, Wilson's nose clip was knocked off. He replaced it with a spare clip he carried in his pocket but had breathed too much bad air and was unable to return to the fresh-air base with the team. According to one report, the retreat signal had been given before Wilson lost his nose clip, and when he saw that he couldn't make it he gave the distress signal. But the men at the fresh-air base did not believe that it was a distress signal because they knew that the team was on its way out. When the team arrived without Wilson it was necessary to check the equipment of the standby team members before they could start, and by the time they reached Wilson it was too late.

Frank Burns, Roy Rushton, and William Heagy

On April 1, 1927, Frank Burns, Roy Rushton, and William Heagy, members of a Valley Camp Coal Co. mine rescue team, lost their lives in the No. 1 mine of the Connellsville By-Products Coal Co., Pursglove, W. Va., while opening a sealed fire area. The men were wearing Gibbs oxygen breathing apparatus.

In sealing the fire several months before, stoppings had been erected at the portal of the main slope, and the crew, consisting of six men, entered the slope through an air lock for the purpose of erecting stoppings to form another fire air lock approximately 425 feet from the mouth of the slope. They did not carry a lifeline, and there was no reserve crew at the fresh-air base. (A reserve crew was available, but the men comprising this crew had been permitted, by those in charge, to leave for lunch.) Burns and his crew had traveled about 225 feet when Rushton showed signs of distress and fell;

whereupon Burns, the team captain, instructed Heagy and two others to remain with Rushton while he and the other crew member returned to the surface to obtain a stretcher and additional help to carry out Rushton, Considerable time was required for Burns to assemble a relief crew on the surface; and when he and his companion, in company with the relief crew, arrived at the point where Rushton had collapsed, it was found that Heagy also had collapsed. Thinking that there was a better chance to save Heagy's life than Rushton's, he was placed on the stretcher and carried out of the mine. Another crew was then organized to go after Rushton; however, when this crew reached the bottom of the slope they found Burns down, with his mouthpiece removed, so they immediately carried him outside. Artificial respiration was applied and oxygen administered to both Heagy and Burns, but they could not be revived. The body of Rushton was not recovered until several hours later because of the demoralized condition of the crews. Finally, a fresh crew from a neighboring mine entered the air lock and recovered Rushton's body.

It is known that Burns and the members of his crew had only a few days training in the use of oxygen breathing apparatus before starting the work in which three of them lost their lives; they were definitely warned that they required more training before engaging in the contemplated recovery operations. It is almost certain that this loss of life would not have occurred if a well-trained crew with a properly trained and equipped reserve crew at the fresh-air base had been used.

Rush D. Hiller

On October 8, 1930, Rush D. Hiller, an undertaker of Canton, Ohio, lost his life while wearing a 1/2-hour McCaa oxygen breathing apparatus on the property of the Dalton Coal Co., Dalton, Ohio.

This accident occurred in a small slope mine in which there was no second opening. A wooden partition had been installed in the 365-foot slope to provide an intake and return airway for the mine. A fire had destroyed the surface buildings and fan near the mouth of the slope and also had destroyed the wooden brattice for about 40 feet down the slope. Three men, who were in the mine at the time of the fire, were killed by carbon monoxide from the fire.

In an effort to reach the three men who were trapped in the mine, Hiller, wearing a 1/2-hour McCaa apparatus, and one of the mine owners and a fireman from Massillon, Ohio, wearing gas masks, entered the slope without a lifeline or a reserve crew at the fresh-air base. No flame safety lamp to indicate oxygen deficiency and no canary or other means of detecting carbon monoxide were carried by the rescue party. When they had gone about 150 feet down the slope, Hiller removed his mouthpiece and remarked that the air was good. He had no more than finished the remark when he collapsed. The other two men attempted to carry him to the surface but became exhausted before they had gone very far; consequently, they left Hiller and proceeded to the surface to get help. Another man put on a gas mask, went down the slope, and tied a rope around Hiller. After Hiller was dragged out of the slope by men on the surface, an attempt was made to resuscitate him by means of artificial respiration and a pulmotor, but doctors on the scene pronounced him dead.

The apparatus worn by Hiller was later inspected by a representative of the Bureau of Mines and found to be in good working condition except for a hole in the inhalation tube, which appeared to have been caused by friction when Hiller and the apparatus were dragged up the slope. Hiller had purchased the oxygen breathing apparatus for his own use. He had no previous training in the use of such apparatus and probably had no knowledge of the dangers of wearing an apparatus in fire gases containing carbon monoxide.

Andrew Wolfgang

On May 16, 1940, Andrew Wolfgang, a foreman of the Philadelphia & Reading Coal & Iron Co. and captain of a mine rescue team, lost his life while wearing a McCaa 2-hour oxygen breathing apparatus, in an attempt to rescue a miner at the bottom of a 50-foot, almost-vertical shaft at a "bootleg" mining operation at Ashland, Pa.

The first victim, a miner, lost his life, according to a press report, when he attempted to return to the bottom of the shaft soon after firing a shot. When he had gone only about 15 feet down the shaft ladder he was overcome and fell to the bottom.

After putting on the apparatus, Wolfgang tied a rope around his body, climbed down the 50-foot ladder to the bottom of the shaft, and attached another rope to the body of the miner. After the miner had been hoisted to the surface, Wolfgang started to climb out and when about 20 feet up stopped for several minutes as if to rest and then started up again. He collapsed about 17 feet from the shaft collar, let go of the ladder, and would have fallen to the bottom had it not been for the rope around his body. When the men on the surface tried to pull him up it was found that the rope had fouled in the ladder, resulting in a delay of about 10 minutes in getting him to the surface. Artificial respiration failed to revive him.

When the body of Wolfgang reached the surface, it was found that the apparatus was intact, with both mouthpiece and nose clip in place, and with 15 minutes of oxygen remaining in the bottle. Subsequent tests disclosed that it was in good working condition. Based upon the facts that Wolfgang was considerably overweight, that he had just eaten his supper when called to the scene of the accident, and that he hurried to get the apparatus up the hill to the shaft, the conclusion was reached that he died of heart failure caused by overexertion and lack of physical fitness.

Reese Phillips and Gray Lacey

On October 6, 1940, Reese Phillips and Gray Lacey lost their lives while wearing Gibbs oxygen breathing apparatus after entering a sealed-fire area at the Wanamie Colliery of the Glen Alden Coal Co., Wanamie, Pa.

Phillips, Lacey, and another man, all wearing oxygen breathing apparatus, entered the sealed area to place a line of hose so that a stream of water could be directed onto a fire. On the way into the fire Phillips complained of trouble with his apparatus, so it was decided to return to the fresh-air

base. After starting back Phillips collapsed, whereupon Lacey became panic-stricken and rushed toward the fresh-air base. The third man followed Lacey and tried to persuade him to return and assist Phillips to safety, but his panic increased. Lacey rushed past the opening leading to the outside of the sealed area, and traveled along an old airway containing numerous falls and many caves. After traveling for some distance along this old airway Lacey climbed on top of a fall and crawled along it until he became wedged tight. When a rescue party arrived to recover his body, it was necessary to cut the apparatus straps before the body could be extracted.

The survivor stated that, after trying to calm Lacey, he returned to Phillips and attempted to drag him to the fresh-air base but was unable to do so. He then returned to the fresh-air base but had to go out of the mine to get assistance. Considerable time elapsed before the bodies of Phillips and Lacey were recovered.

After the foregoing was published in 1944, the Bureau of Mines received a letter from a man who should have been in a position to know the facts of this case. His version is as follows:

> Lacey, who was quite experienced in wearing breathing apparatus, did not become panic stricken. He was investigating conditions to find a less-obstructed way from the fire to the fresh-air base. In so doing, Lacey was climbing over a fall on top of a large slab of rock which was considerably tilted. He slid down this slab of rock and his breathing apparatus became wedged against another rock and he could not free himself.
>
> The surviving member of this party of three, J. O. Smith, did not go out of the mine for assistance, as 11 men were stationed at the fresh-air base not more than 25 feet from Reese Phillips' body. The time elapsed before assistance came was not more than 5 minutes, and Phillips' body was removed immediately to fresh air, where he was given artificial respiration and an inhalator was used for more than an hour.
>
> Others of the party went immediately to Lacey's rescue, but owing to the difficulty experienced in freeing his body and the time consumed in building ladders and crawlways, about 1-1/2 hours had elapsed before Lacey's body was brought to the fresh-air base.

Arthur Kaemmerer

On March 28, 1955, Arthur Kaemmerer, 40 years of age, was asphyxiated in the Little Oak mine, Belleville, Ill. He was an experienced salvage operator and not a mining man. The fan was in operation and ventilation had been partly reestablished for about 3,000 feet inby the shaft bottom. Kaemmerer had obtained the help of Andrew Yuengel, who was regularly employed at a nearby coal mine, in further exploring the Little Oak mine preparatory to salvaging rails, wire, etc.

On the morning of March 28 Kaemmerer and Yuengel entered the mine through the main shaft, leaving two workmen on the surface. The purpose of the trip was to explore part of the main west haulage road. Each man carried a carbide lamp, a permissible electric cap lamp, and a nonpermissible Bendix back-type oxygen demand mask equipped with a 38-cubic-foot oxygen tank. In addition, Yuengel carried a permissible flame safety lamp.

About 3,000 feet from the shaft bottom the flame of the safety lamp went out because of oxygen deficiency. When this happened the oxygen demand masks were put on, and the investigation continued for about 20 minutes more before the men turned back. After traveling about 100 feet Yuengel's oxygen supply was exhausted. He removed his mask and staggered another 100 feet, with some help from Kaemmerer, and then collapsed. Kaemmerer tried to pick Yuengel up, but found he was unable to stand. Yuengel told Kaemmerer to go on out and get help. Yuengel rested on the mine floor for about 15 minutes without losing consciousness and then struggled back about another 100 feet. He kept resting and retreating in this manner for about 600 feet toward the shaft, at which point he found Kaemmererfs body. His hasty examination convinced him that Kaemmerer was dead, so he resumed his tedious journey to the shaft, alternately resting and traveling. Upon reaching the shaft bottom he signaled the men on top by hammering on the bucket used for entering the mine. The top men lowered the cable, which Yuengel hooked to the bucket, and he was hoisted to the surface. He sent one of the top men for help, and several hours later two mine rescue teams arrived, and Kaemmerer's body was brought to the surface.

This accident varies considerably from others covered in this publication, but it is an excellent illustration of what not to do when entering an abandoned mine. Any person intending to enter an abandoned mine should follow the advice of people having knowledge and experience in such procedure. In many States it is unlawful to enter or reopen abandoned mines without the guidance of a State mine inspector.

THE THREE PERIODS

The 26 accidents resulting in 35 fatalities covered herein fall naturally into three groups (see table 1). The first group of 20 accidents involving 26 fatalities occurred between December 24, 1908, and December 31, 1921, covering 13 years. The second group of 5 accidents involving 8 fatalities occurred from January 1, 1922, to October 6, 1940, covering nearly 19 years. The third and last period, from October 1940 to July 1959, covers nearly 19 years, in which there was only 1 fatality.

The first period in which the average was about 2 lives lost each year is the important one, because it was during these years of trial and error that the lessons were learned and the rules established which have since made the wearing of oxygen breathing apparatus in irrespirable atmosphere much safer. During these 13 years, 13 men lost their lives while wearing Draeger 2-hour apparatus, and the stories of some of these fatal accidents indicated certain fundamental weaknesses in the type of Draeger apparatus then in use. Six men lost their lives while wearing Fleuss 2-hour apparatus. There were 4 additional deaths in which the type apparatus worn is unknown; however, from the

dates and geographical area in which the accidents happened it is apparent that either Draeger or Fleuss apparatus were worn. Gibbs apparatus were worn by 2 of the men who lost their lives during the latter part of this 13-year period.

The second period of nearly 19 years (January 1922 to October 1940) might be regarded as a transition period in which the lessons learned in the first 13 years were being applied by more and more teams. The Gibbs and Paul apparatus were given Bureau of Mines approval on February 15, 1920, and in 1923 the Bureau of Mines published Technical Paper 334, Mine Rescue Standards. During this 19-year period there were 5 accidents in which 8 lives were lost. Six of the victims were wearing Gibbs apparatus, one a McCaa 2-hour apparatus, and one a McCaa 1/2-hour apparatus.

In the one accident during the third period (October 1940 to July 1959), a Bendix 1/2-hour apparatus was worn.

A study of the 26 accidents to wearers of oxygen breathing apparatus reveals that from 3 to 9 of the presently accepted safety rules advocated by the Bureau of Mines were broken in each accident. The principal ones are listed as follows:

1. There were less than 5 men on the team in 13 accidents in which 17 men lost their lives.

2. The crew split up after the distress of a member on 17 occasions where 25 lives were lost (sometimes justifiable when a man is nearly out of oxygen).

3. Either no reserve crew or an insufficient reserve crew (less than 5 men) was at the fresh-air base on 20 occasions where 29 lives were lost.

4. Either no lifeline was carried or the team traveled beyond the lifeline in 19 instances in which 26 lives were lost.

5. Apparently 5 lives were lost in 5 separate accidents because of the poor physical condition of a team member.

6. On 2 occasions, which resulted in 3 fatalities, training maneuvers were conducted in dangerous atmosphere.

7. Failure to obey instructions contributed to 2 deaths.

8. Traveling too far from the fresh-air base was a contributing factor on 6 occasions in which 10 lives were lost.

9. Insufficient training in wearing the apparatus contributed in 7 instances to the death of 9 men.

TABLE 1. - Lives lost while oxygen breathing apparatus was being worn

Name of victim	Date	Mine	Company	Location	Type of apparatus
			First period		
Otho Graves.....	12/24/08	Zeigler No. 1	Zeigler Coal Co.	Zeigler, Ill.	Draeger 2-hour.
Henry Bucham.....	1/29/09	do.	do.	do.	Do.
E. A. Sutton.....	2/ 9/11	Cokedale	Carbon Coal & Coke Co.	Carbondale, Colo.	Do.
Joseph E. Evans....	4/ 7/11	Pancoast	Price-Paneoast Coal Co.	Throop, Pa.	Do.
John Farrell.....	1/19/12	No. 2	Pittsburgh & Eastern Coal Co.	Cherry Valley, Pa.	Do.
William McColligan.	4/23/13	Cincinnati	Pittsburgh Coal Co.	Courtney, Pa.	Do.
Edward Evans.....	9/30/13	No. 1	The Union Pacific Coal Co.	Rock Springs, Wyo.	Do.
James Laird.....	10/22/13	No. 2	Stag Canon Fuel Co.	Dawson, N. Mex.	Do.
B. Poyser.....	do.	do.	do.	do.	Do.
Gomer Phillips.....	5/25/15	No. 1	Smokeless Coal Co.	Johnstown, Pa.	Fleuss 2-hour.
Thomas Hendrickson.	9/17/15	Quincy Tunnel	Albion Mining Co.	Salt Lake City, Utah	Draeger 2-hour.
Lewis M. Jones.....	10/20/16	No. 7	Jamison Coal & Coke Co.	Barrackvllle, W. Va.	Fleuss 2-hour.
Walter Kerr.....	5/ 6/17	Hastings	Victor-American Fuel Co.	Hastings, Colo.	Draeger 2-hour.
Samuel T. McMahon..	11/13/17	No. 7	Jamison Coal & Coke Co.	Barrackvllle, W. Va.	Fleuss 2-hour.
Bryce Warren.....	do.	do.	do.	do.	Do.
David Murphy.....	2/26/18	Government	Carthage Fuel Co.	Carthage, N. Mex.	Do.
William Taylor.....	6/29/18	No. 8	O'Gara Coal Co.	Eldorado, Ill.	Draeger or Fleuss.
Robert Kennedy.....	do.	do.	do.	do.	Do.
Loren Whitler.....	do.	do.	do.	do.	Do.
James S. Cunningham	8/25/19	Gasoline Tank	Sinclair Oil & Refining Co.	Trinidad, Colo.	Salvus 1/2-hour.
Henry DeWinter.....	7/10/20	Black Diamond No. 2	Pacific Coast Coal Co.	Black Diamond, Wash.	Draeger 2-hour.
Hugh Hughes.....	do.	do.	do.	do.	Do.
James Hudson.....	do.	do.	do.	do.	Gibbs 2-hour.
Philip White.....	7/29/20	No. 18	By-Products Coal Corp.	West Frankfort, Ill.	Draeger or Fleuss.
Thomas Ritson.....	9/ 2/21	Harco	Harrisburg Collieries Co.	Harrisburg, Ill.	Fleuss 2-hour.
Albert Gilmore.....	12/31/21	No. 1	Ellsworth Collieries Co.	Ellsworth, Pa.	Gibbs 2-hour.
			Second period		
George Wilson.....	3/ 9/24	Castlegate No. 2	Utah Fuel Co.	Castlegate, Utah	Gibbs 2-hour.
Frank Burns.....	4/ 1/27	No. 1	Connellsville By-Products Coal Co.	Pursglove, W. Va.	Do.
Roy Rushton.....	do.	do.	do.	do.	Do.
William Heagy.....	do.	do.	do.	do.	Do.
Rush D. Hiller.....	10/ 8/30	Dalton	Dalton Coal Co.	Dalton, Ohio	McCaa 1/2-hour.
Andrew Wolfgang....	5/16/40	"Bootleg"	Anthracite Operation	Ashland, Pa.	McCaa 2-hour.
Reese Phillips.....	10/ 6/40	Wanamie	Glen Alden Coal Co.	Wanamie, Pa.	Gibbs 2-hour.
Gray Lacey.....	do.	do.	do.	do.	Do.
			Third period		
Arthur Kaemanerer..	3/28/55	Little Oak	Salvage Operation	Belleville, Ill.	Bendix.

10. Apparently a physical examination was not given the men before they entered the mine on 16 occasions where 20 lives were lost. Before 1918 physical examinations were seldom given to apparatus members.

Properly trained teams and reliable equipment were responsible for the eventual decrease in deaths, but the change was gradual, and it took the second period of 19 years to bring the fatal accidents to their present low level. The 8 fatalities of the second period and also the 1 of the third period all had about the same contributing causes as those of the first period; however, Gibbs and McCaa apparatus were in general use and equipment failures were few. It took a long time for everyone to learn the importance of the rules outlined in the next section.

LESSONS LEARNED

The circumstances surrounding the fatal accidents to men wearing oxygen breathing apparatus have led to greatly improved apparatus and also to definite safety procedures or rules, the more important of which are listed as follows:

1. Explorations or other work ahead of fresh air should not be attempted with a crew of less than five men.

2. Members of a crew should not separate from other crew members while ahead of fresh air unless it is absolutely necessary to do so.

3. A lifeline or, preferably, a lifeline telephone should be used as a means of communicating with the fresh-air base while exploring or working ahead of fresh air.

4. A fully equipped reserve crew of not less than five men should be kept in readiness at all times at the fresh-air base while exploration or other work is in progress ahead of fresh air.

5. Apparatus should be thoroughly tested immediately before being used in a dangerous atmosphere.

6. Apparatus men should be given a thorough physical examination by a physician before being considered qualified to wear oxygen breathing apparatus. They should also be reexamined by a physician shortly before wearing apparatus at a mine fire or explosion.

7. The team captain should follow, as nearly as possible, the instructions given him by the responsible official at the fresh-air base.

8. Crew members should obey their captain at all times while working in advance of fresh air, regardless of circumstances.

9. The length of trips made while wearing oxygen breathing apparatus should be limited to not more than 1,000 feet when the way is clear, except

in extreme emergencies where life is involved, When there are falls, bodies of water, or other obstructions, and on steep grades, the length of travel should be proportionate to the difficulty of travel.

10. No person should be considered qualified to wear oxygen breathing apparatus at a mine fire or explosion unless he has taken the Bureau of Mines standard course or its equivalent, and he should not be considered qualified unless he has received additional training in mine rescue work within the past 12 months.

11. The crew should be trained fully in the procedure to follow if a crew member is in distress or collapses.

12. A crew traveling or working ahead of fresh air should carry a stretcher unless a lifeline telephone is used, in which case stretchers may be brought up promptly by the reserve crew if the need arises.

13. When one or more members of a crew show signs of distress, warning should be given immediately to the fresh-air base, and the crew should start to retreat toward the fresh-air base leading the distressed member or carrying him on a stretcher, as the case may require.

14. Upon receipt of a distress signal or call, the reserve crew should proceed immediately toward the crew in distress, and upon meeting it should assume the burden of the distressed member or members.

15. Communication between team members should be accomplished by means of signals, and no attempt should be made to speak while oxygen breathing apparatus is being worn in irrespirable atmosphere unless the approved facepiece with a speaking diaphragm for use with the McCaa 2-hour breathing apparatus is worn.

16. Mine rescue crews should be trained as units, and substitutions should not be made unless absolutely necessary.

17. Apparatus men should not eat a heavy meal immediately before wearing apparatus.

18. Apparatus crews should be fully rested before attempting to do work or explore ahead of fresh air.

19. Apparatus men should not breathe air containing carbon monoxide or other toxic gases before wearing breathing apparatus ahead of the air.

20. Apparatus-crew members should be required to have a practical knowledge of mine gases and to have had practical underground mining experience.

21. Apparatus men should not enter tanks or other openings alone unless fitted with a safety belt attached to a rope leading to fresh air. There should be enough men at the fresh-air opening to be able to pull the dead weight of the man and the apparatus out of the opening.

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