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Creators: Nold, H. E. (Henry Ellsworth), 1883-1967

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Mine Illumination

By H. E. NOLD, *Assistant Professor, Mine Engineering*

The proper illumination of the working forces in coal mining is a considerably more difficult task than the illumination of a manufacturing plant or office. The problem is complicated by the fact that the black coal walls or "ribs" which surround the workers do not reflect light as do the colored walls and ceiling of ordinary buildings.

Also illumination by means of ordinary incandescent electric lamps is impracticable owing to the cramped quarters and because the wires would be torn down every time a shot was fired to break down the coal.

In addition to the difficulties named above, in a great many coal mines the fresh coal at the working faces liberates methane (CH_4) into the atmosphere in such quantities as to make any open flame lamp unsafe and under like conditions the ordinary incandescent electric lamps are unsafe, due to the fact that they are apt to ignite the CH_4 and air mixture, "fire damp," if the globe should become broken.

The only practical method of illumination yet devised is one in which no attempt is made at uniform lighting of the working face, but the light is carried by the miner, usually on the front of his cap and directed upon the place to be illuminated.

Non-gaseous Mines.

In a so-called "non-gaseous" mine, i. e., a mine in which not enough CH_4 is given off by the strata to make a dangerous atmosphere, the problem is comparatively simple.

In such non-gaseous mines, generally some form of open flame light is used. The ordinary paraffine candle makes a very satisfactory light except that it does not give as much light as desirable. Until within the last ten or twelve years the favorite miner's lamp in non-gaseous mines was the ordinary oil torch, burning lard oil and provided with a hook to fasten it to the front of the miner's cap. Such a light was dirty and greasy and smoked considerably. It has a candle power of from 1.4 to 1.9.

The miner's carbide lamp has recently become a great favorite with the men in non-gaseous mines. It is made in small sizes so that it can be carried on the cap. Such a lamp is clean, does not smoke and, when fitted with a reflector, gives a candle power head on of 4.2 to 6.2 and at right angles to the flame of 0.87 to 1.45.

One can readily see that such a light leaves much to be desired and necessarily the efficiency of the workmen is not what it could be with better illumination. The carbide light, however, is the best and most satisfactory open flame miner's lamp now in use. It enables a man to see quite clearly for a distance of ten or twelve feet and throws the light where it is most needed.

Gaseous Mines.

In gaseous mines the amount of CH_4 given off by the strata is such that at times it reaches dangerous proportions and it is at all times a factor to be reckoned with.

In such mines an open flame light is a constant source of danger. It is a fact that the initial explosive agent in most mine explosions is CH_4 (methane) and the agent of ignition is usually a blown out shot, a short circuit, electric spark or the flame from a miner's lamp.

The history of the early days of coal mining in England is full of accounts of death due to gas explosions and the agent of ignition was almost always the miner's candle o rlamp. In fact in the latter part of the 18th and the early part of the 19th centuries this trouble became so great as to menace the very existence of coal mining.

The method used in England in the last half of the eighteenth century to get rid of the gas was by firing it. This was done by a man, called a "fireman," dressed in coarse cloth or leather dampened. The fireman would lie prone on the floor of the mine passage and light the gas (CH_4+air) above him by raising a candle or torch fastened to the end of a long stick. If he survived, which was frequently not the case, he would withdraw to fresh air as soon as the flame had passed over him.

Another method of keeping the mine clear of gas was the use of the so-called "eternal lamps." These lamps were kept constantly burning in the cavities of the roof where the gas tended to accumulate. The purpose of the lamps was to burn the gas as fast as it came from the strata. The large number of fatalities from such practices led to many experiments to attempt to develop a means of mine illumination which would not fire the gas, among other things attempts were made to illuminate the workings by means of various phosphorescent substances.

The "steel mill" was invented by Carlisle Spedding, a young English miner. It consisted of a thin disc of steel, so mounted in an iron frame that it could be rotated at a rapid rate by means of a spur-gear and hand-crank. A piece of flint held against the rim of the rapidly moving wheel caused a bright shower of sparks, which gave considerable light as long as it lasted. A boy was employed to turn the mill.

The safety feature of the steel mill was due to the fact that the ignition temperature of CH_4 is about 700° C. and the sparks from the wheel are, first, too short-lived to readily ignite the gas, and, second, do not generate enough heat to do so unless the wheel is turned quite rapidly.

In spite of all these precautions the explosions of 'fire-damp" continued without appreciable abatement until the invention of the safety lamp early in the nineteenth century.

Dr. William Reid Clanny of England, in 1813,

constructed the first safety lamp. The lamp consisted of an upright cylindrical metallic case, made air-tight and fitted with a semi-circular glass front. The cylinder was topped by a metallic conical tube or cap, which ended in a long narrow tube opening. Within the case was a candle. The air necessary for its combustion was forced through a water seal in the bottom by means of a hand bellows. The products of the combustion, escaping through the narrow opening at the top of the conical tube, prevented the passage of the flame out at that point. The flame of this lamp was, therefore, completely isolated from the outer mine atmosphere, but the constant attention necessary to keep the lamp supplied with fresh air prevented its general adoption in the mines.

In 1815, Sir Humphrey Davy published his discovery of the wonderful property of wire gauze, which under certain conditions would permit the free passage of air through its mesh, while it presented a solid wall to the flame.

Every student of chemistry has noticed that if a piece of wire gauze is held horizontally above the flame of a Bunsen burner and then slowly lowered, the flame is confined below the wire gauze. If the student now takes a match he can ignite the gas above the gauze and it will continue to burn both above and below. Observation will show him that the flame is not in direct contact with the gauze on either side. If the student continues to hold the gauze in the flame without igniting the gas above the gauze, it will confine the flame below it until the gauze becomes red hot (ignition temperature of CH_4) at which temperature the gas will ignite above the gauze.

The principle of the action of the wire gauze is two-fold.

First. Extinction of flame by the cooling effect of wire gauze.

Second. Extinction of flame by breaking it up into many small individual streamlets.

Davy found that the effectiveness of wire gauze in prohibiting the passage of flame, varied with the size and kind of wire used and the size of the openings between the wires.

The greater the specific heat of the material the more effective the gauze. He found by experiment that the most effective gauze is a steel wire gauze containing twenty-eight wires (No. 28 B. W. G.) to the inch, or 784 openings per square inch. This has continued and is still the adopted standard wire gauze for safety lamps.

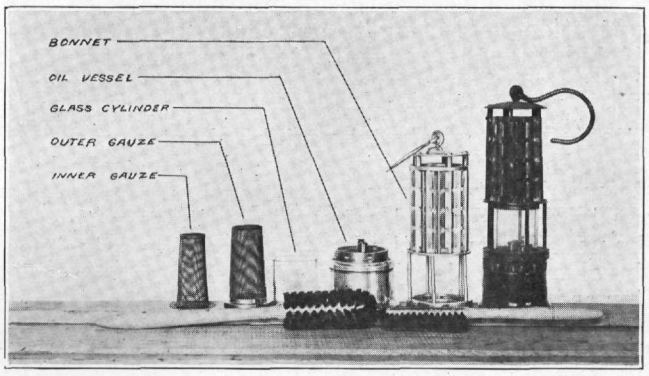
Sir Humphrey Davy applied his discovery to mine illumination by placing a cylinder of wire gauze, closed with gauze at its upper end, over the flame of a lard or sperm oil lamp. He thus had a light enclosed in a combustion chamber, the walls of which would freely admit air on all sides, but presented an impassable barrier to the flame, so that the flame in the lamp could not ignite the fiery mine air. In practice the gaseous mine air passes through the gauze into the combustion chamber where the CH_4 burns as a faint blue envelope or "cap" surrounding the oil flame.

The lamp is safe so long as it is not moved too quickly, thus jerking the flame through the gauze or until the gauze becomes red hot and ignites the mine air.

The most effective size gauze has been found to be about 1½ inches in diameter and from 4½ to about 7 inches long.

The safety lamp has one other function in addition to giving light. By watching the size of the "cap" the miner is able to estimate the percentage of CH_4 present in the air. The lamp thus becomes an indicator warning him of the foulness of the atmosphere and allowing him to retreat to fresh air.

All modern gauze safety lamps are improvements of the original Davy lamp. The first safety lamp gave only about 0.16 candle power. By raising the gauze and surrounding the flame with a heavy glass cylinder, the illuminating power of the lamp was raised to nearly one candle power. Another improvement has been to use two gauzes, one inside the other, thus giving double protection. In order to protect the flame from strong air currents the gauzes are now generally surrounded by a perforated metal bonnet.



Wolf Safety Lamp

A modern safety lamp, popular in the United States, is shown in the illustration. This Wolf lamp burns gasoline, has a glass cylinder surrounding the flame and uses two gauzes protected by a metal bonnet. This lamp will burn for about ten hours and gives almost one candle power.

In the last five years a new type of electric light has been developed which is popular in gaseous mines. This is a small incandescent lamp (about 2 to 2½ candle power) mounted in a reflector which is fastened to the miner's cap and from which insulated wires pass down the man's back and are attached to a small storage battery carried on his belt. By using low voltage and a specially constructed bulb attachment and cover, these lamps are made strong and will not ignite the gas even if the globe is broken. These electric lamps are a great improvement, in illuminating power, over the gauze safety lamps, but they lack one very important feature necessary for their safe use in very gaseous mines.

Their weakness is that they give the miner no warning of his entrance into a dangerous or suffocating atmosphere and he is, therefore, liable to be overcome without realizing that he is in danger. Until some indicator is developed which can be used by the miner to warn him of a dangerous atmosphere, the electric light, in spite of its desirability as a source of light, will find its main use in those mines generating only moderate amounts of CH_4 sufficient to cause a mine fire or explosion but not sufficient to asphyxiate the miner.