MINE LIGHTING

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Historical

The first written record of the use of coal in England is found in a receipt of "twelve cart loads of coal" by the Abbey of Peterboro in the year 852 A. D., but it is doubtful whether the Anglo-Saxon word "coal" does not mean peat. The first record of actual mining operation is in the books of the Bishop of Durham, 1180 A. D. A legal document in Scotland shows the conveyance of a mine in the year 1210. Coal was certainly sold as an artcile of commerce in the year 1215, likewise the date of Magna Charta; and this latter date may be safely taken as the year in which coal mining became established as a business in England on a commercial basis.

In the United States coal mining has been in operation about 170 years. The earliest mention of coal dates back about 220 years.

The history of mine lighting shows an equal antiquity with coal. The problem of how to obtain a safe and efficient mine lighting system arose as soon as the outcrop had been pierced, and has continued until our day. We shall see that on several occasions it has been solved with apparent satisfaction and great rejoicing amongst the workmen; but in a comparatively short time the manifestation of unrest on the part of both miner and operator showed that somewhere there was a fault, somewhere an imperfection, whether in lack of illumination or of safety, that needed to be remedied before success could be assured. When we reflect that mining of coal has been carried on for several centuries we are naturally interested in the solution of a problem so much affecting the security of man. We inquire what progress has been made during this time. To answer this latter query has been the inspiration of this narrative, in which it is intended to trace the successive steps in the development of mine lighting and the conscientious endeavors of men to add to the happiness and safety of their fellow men.

Primitive Methods of Lighting

The early Romans, we are told, used large torches and lamps fed with tallow for mine lighting. The Japanese lighted many of their mines in the same way, and continued this method as late as 1890. In England torches are believed to have been used for lighting the outcrop workings. To ignite these flint and tinder were used and sometimes by briskly rubbing together two dry sticks, which kindled owing to friction. On the Continent relics in ancient mines furnish bases for the belief that earthen oil lamps, similar in shape to those now made, were used instead of torches.

As time went on and workings spread out the ignition of gas and explosions became frequent. In the former event the men were often seriously or fatally burned; in the latter the effects, though disastrous, must have been confined within comparatively narrow limits; but the menace of gas was increasing, and a great fear sprung up in the hearts of the workmen. The fact that the behavior of gas was mysterious and little understood added to its terrors. It was plainly to be seen that the use of torches, oil lamps and candles was fraught with dangers.

These workmen now did the very natural thing to do—they sought a substitute for the flaming lights. Dried fish skins, from the scales of which a faint phosphorescent light was given, were brought into use. A mixture of flour and lime, made from oyster shells, and called Canton phosphorus, was tried. Unknowingly, they adopted the method used by their fellow workmen in Brazil, namely, fire-flies in a bottle. In Flanders amadon, or fungus tinder, was employed in dangerous parts of the mines; but these, and a few other attempts to derive light with safety, had a common defect in that the light yielded by the substance was much too feeble to enable men to work successfully. Again, men were unable to examine the roof for weak places, and fatalities from falls increased. In their despair a few voluntarily chose to work in the dark in gaseous places, and the man who could so work was held at a premium.

Mining of Coal Stimulated by Inventions

Mining advanced slowly up to the year 1710. The problems of haulage, hoisting, pumping, etc., were as troublesome as that of lighting. At that time 350 feet was about the maximum depth of shaft, and the area worked to one shaft was seldom more than a 600 foot radius. Most of the coal was obtained from shallow openings and proved sufficient to meet the light demands; but the invention of the atmospheric engine by Thomas Newcomen, in 1710, changed the entire aspect of the industry. It offered the mine owner mechanical power for those places where theretofore man-power had been used. Hoisting and pumping, especially, could be greatly facilitated, and the British colliery owners eagerly adopted Newcomen's invention, crude though it was. Everywhere it was hailed as the most wonderful achievement of ages. When James Watt, in 1763, began experimenting on steam and improving the construction of engines, it drew the attention of a number of men more or less familiar with mechanics to the steam engine, and resulted in the adoption of many good features.

The direct result of these improvements was the adoption of the steam engine in all industries. This, in turn, created a demand for coal, and it became evident to colliery owners that preparations must be made to meet it. The shallow workings which had furnished sufficient fuel to meet the demand for "house" coal were inadequate, now that a cry for coal arose from all quarters. It was obvious that shafts must be sunk to lower measures and that the problems of deeper mining must be confronted.

The increase in depth and the extensions of working limits brought on an increase of gas in the workings. Ventilation had not received much attention; in fact, it was not deemed a necessity.

It might even become a menace, as it was known that gas was more violently explosive at such places as had a small current of air; and, further, is was believed that gases resulting from the burning of candles in stagnant places made fire-damp less explosive.

The Use of Eternal Lamps

A bold measure was now suggested, based on the principle that if the accumulation of gas could be prevented small amounts could do no harm. The plan consisted of burning lamps, candles, or torches continuously in all fiery places in the mine, so that the gas would be consumed as rapidly as generated. These lights were called "eternal lamps" and, as the name implies, were kept burning continuously night and day, Sundays and holidays as well. In several places this idea was carried out successfully, but on account of the smoke given off in the stagnant air, this method of fighting fire with fire had to be abandoned in most cases.

The Steel Mill

It was during these days of uncertainties that Sir James Lowther became interested in collieries as an operator. He at once took a great interest in the problem of overcoming the menace of gas. A young man in his employ, named Carlisle Spedding, had early attracted his favorable notice on account of the great interest he manifested in all phases of mining. Accordingly, Spedding was sent to Newcastle-on-Tyne to thoroughly learn the methods of mining so that he should be competent to assume charge of Sir James' collieries.

Carefully concealing his name and purpose, Spedding procured work as a miner, and applied himself to the learning of all that pertained to mining. One day he was seriously burned in an ignition of fire-damp, and he was obliged to reveal his identity and purpose of employment. Upon recovery from his injuries he resumed his labors, and in 1750 rewarded the confidence Sir James had reposed in him by originating the "steel-mill." This mill consisted of a thin disk 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. The light was produced by holding a piece of flint against the rim of the rapidly-moving wheel, causing a bright shower of sparks. These sparks were not considered capable of igniting fire-damp. Spedding knew that flint and steel had been used as early as 1733 in gaseous places, and the steel-mill was merely an elaboration of this idea.

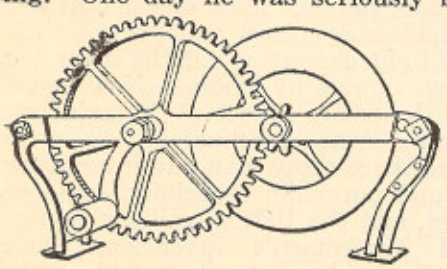


Fig. 1. The Steel Mill.

These mills were operated mostly by boys. They were carried by means of a leather band passing through the back end of the frame and about the neck of the operator. This permitted the use of both hands to press the flint against the wheel rim. Frequently several steel-mills had to be "played," as it was called, in one place at the same time in order to provide sufficient light. The cost of operating them was high, and it is stated that the wages of the "players" in an ordinary colliery amounted to as high as $800 per month.

The steel-mill was eagerly adopted, however, and much confidence was placed in the statement that it would not ignite the gas. Whatever faith remained up to 1785 that the steel-mill would not cause an explosion was decisively shattered, as may be inferred from the following entry in Sykes' Local Records of Northumberland and Durham,* etc.:

"June 1785. An explosion occurred in Wallsend colliery by which one man lost his life. This was the first explosion which was distinctly known to have taken place at the steel-mill. Some doubt remained up to this time as to whether the fire-damp would explode at the spark of the steel-mill or not; but the fact was clearly ascertained on this occasion, as the person, John Selkirk, who was playing the mill at the time, survived the accident."

Wallsend was the deepest colliery on the Tyne, being stated by Brand, in 1787, to be 630 feet deep.

This explosion had caused damage to the shaft, and the following entry is interesting, as showing the date at which attempts were first made to use reflected sun-light for lighting underneath:

"In repairing the shaft after these explosions the mode of throwing the rays of the sun down a shaft by a mirror, so as to light it, was accidentally discovered in the following manner: While the people were working in the shaft at about 80 fathoms (480 feet) from the surface, a carpenter was employed to do something at the head-framing, immediately above the mouth of the shaft, and in using his saw he accidentally turned the bright blade of it so as to throw a pencil of the sun's rays suddenly down the pit, to the great terror of the workmen below, who thought the pit had fired again. The cause of their alarm however, being soon discovered, it suggested the idea of applying a mirror to throw the light of the sun down the shaft, which mode of lighting has since been frequently resorted to when other lights could not be used."

As might be expected, attempts were made to reflect the light from the shaft bottom back into the workings, but, owing to losses due to obstructions and dust, it was impossible on the brightest days to light workings, however limited in extent.

The steel-mill increased in favor for the simple reason that it was the best device known, and it was generally adopted for use in gaseous workings and in those collieries where explosions had just taken place. The light given off by it was feeble, unsteady, and otherwise unsatisfactory, and many miners preferred to take the risk of using flaming lights. By the year 1800, however, steel-mills had a wide use, and were, as a measure for safety, superior to candles; but many accidents no doubt resulted from their use, and the use of candles. Explosions continued to grow more violent and more destructive to life and property. In an explosion in one of the collieries under his charge Spedding himself was killed, thus ending, prematurely, a life full of rich promise to the coal industry.

*"The Colliery Manager's Handbook"—Pamely.

Origin of Mining Institutes

These calamities aroused much sympathy and men began to concentrate their energies toward arriving at some solution to the problem of mine lighting that would have permanence.

J. J. Wilkinson, a London barrister, believed that most of the disasters could be attributed to the apathy existing among the operators, and that all that was needed was a concerted effort for betterment. He issued a call to the prominent coal men in the Northumberland and Durham colliery districts, inviting them to attend a meeting to be held to form a Society for the Prevention of Colliery Accidents. There was a ready response on the part of all, the clergy especially endorsing the idea, and the society was formed.

However, before the formation of the London Society the interest of two men in the second principle, i. e., the invention of a safe lamp, had been excited. First, Baron von Humboldt, the celebrated philosopher and traveler, in 1796, had made the plan of a lamp for use in the dangerous sections of a mine. The flame was entirely insulated from the air, and could burn only for a short time, or until the air contained within the lamp was exhausted. It was of such inconvenient construction that little was heard of it.

The second man was Dr. William Reed Clanny of Sunderland, a physician whose practice largely consisted of the treatment of men injured in the mines. He described, before a local Society for Prevention of Mine Accidents, organized in his home town, a lamp which he had constructed, and which he hoped would do much toward eliminating the dangers of fire-damp.

The Clanny Lamp

The flame of this lamp was insulated, and the air supply necessary for its combustion was forced, by means of a bellows, through a stratum of water placed in the bottom. A second layer of water was arranged above the flame, through which the products of combustion escaped. The water thus prevented the passage of flame out of the lamp. In an explosive atmosphere the light went out. Scientific men, amongst others Dr. Wollaston, Mr. Pepys, and Baron Berzelius, the great Swedish chemist, approved of Dr. Clanny's lamp, but the colliery owners, to his great surprise, gave him no encouragement. This was no doubt due to the fact that shortly after the formation of the national society, Mr. Wilkinson, believing that such a vexatious problem could be solved only by the most renowned scientists, had written Sir Humphrey Davy, asking for his active co-operation. This letter, unfortunately, did not reach Sir Humphrey.

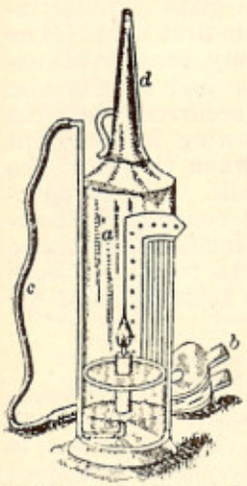


Fig. 2. Early Type of Clanny Lamp.*

When it became apparent that the lamp of the unknown Clanny was to receive no recognition at the hands of the national Society it was decided by Clanny's followers to appeal the matter to the people, and the power of the press was invoked. J. H. H. Holmes called public attention to Dr. Clanny's lamp, and demanded a trial of it, which was finally granted. The lamp proved to be unsuccessful when tested in an inflammable mixture of air and gas at the Herrington Mill colliery, on October 16, and again on November 20, 1815—more than two years after Dr. Clanny's description before the local society at Sunderland. Clanny's first lamp was, therefore, never used in collieries.

The summer of 1815 should ever be held in memory as one of the most notable periods in coal mining. It was at this time that Dr. Murray and Mr. Brandling sought to improve on the Clanny lamp. George Stephenson began to experiment by burning candles to windward of lighted blowers; Sir Humphrey Davy's services were engaged by the national society; and J. H. H. Holmes, ably assisted by Dr. Clanny, aroused a keener public interest through contributions to the press on safety-lamps.

Investigations of Sir Humphrey Davy

The most important event of the summer was, undoubtedly, the advent of Sir Humphrey Davy into the field of investigation. It is true that much had been accomplished before he took hold, but the rapidity with which his mind, trained to separate the chaff from the wheat in science, grasped the real need of the situation is one of the most remarkable achievements of man.

In August, 1815, Sir Humphrey Davy visited a colliery near Newcastle-upon-Tyne to see for himself the behavior of gases in the mines. Upon leaving he ordered that a sample of fire-damp be sent to him, and in fourteen days from the time the sample left the colliery for London by wagon Davy announced his safety-lamp, the principle of which is found in all oil safety-lamps of this day. On November 9th, of the same year, he read his celebrated paper on fire-damp before the Royal Society of London, in which was a fascinating account of his experiments leading to the invention of the lamp.

In brief, he first tried phosphorus, and likewise the electric light in closed vessels, but without success. He also had a lamp constructed with two valves which closed automatically in an atmosphere contaminated with fire-damp, due to the increased heat of the flame produced by the combustion of the gases. He next turned his attention to flame. In his experiments it was made plain that methane required a large proportion of air to make it explosive. He experimented with small metallic tubes and sieves of brass and iron wire-gauze, which he found, under certain conditions, prevented the passage of flame. To quote from his paper:

"I have already discovered that explosive mixtures of mine-damp will not pass through small apertures, or tubes; and that if a lamp or lantern be made air-tight on the sides and is furnished with apertures to admit the air it will not communicate flame to the outward atmosphere. Again, I have discovered that gas mixed in any proportion with common air will not explode in a small tube, the diameter of which is less than 1/3-inch.

After series of experiments Davy enclosed his flame in a wire-gauze 1/40 to 1/60 of an inch in diameter and having 784 apertures to the square

*From "Mine Gases and Explosions," J. T. Beard.

inch. This gauze was made into a cylinder 10 inches long, two inches in diameter, and closed at one end with wire-gauze, thus forming a cage. A lighted candle was inserted at the open end, soft clay being used to fill the space between the candle and the gauze to exclude the passage of air or gas. When this lamp was introduced into a gaseous mixture it was found that the gas passed freely into the lamp and was exploded there, but the ignited mixture did not pass out of the gauze and ignite the explosive mixture surrounding the lamp. If the fire-damp was in sufficient quantity the candle went out. Davy also noticed that after an internal explosion had occurred the mixture continued to burn, and that the gauzes were heated to redness. He had previously discovered that when the gauze was heated to a dull redness the flame would pass through the finest wire gauze meshes, and that external fire-damp was then lighted. He was therefore aware that the use of his lamp would not be a guarantee of immunity from danger; it would merely minimize it.

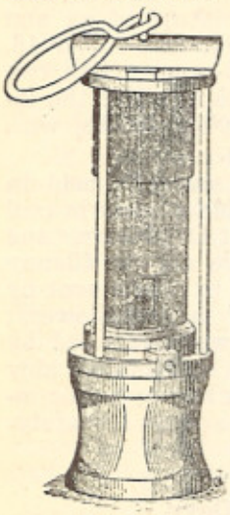


Fig. 3. The Davy Lamp.

A lamp was now built to withstand mine usage, the gauze being the same as in the candle-lamp, except that supplementary gauzes were added to the top of the cylinder to increase the cooling surface at the critical point. An oil cup was introduced instead of a candle, and the lamp was supported and protected by three upright bars joined at the top to form a loop, to which a ring was attached as a handle. The lamp in this form was first used at Hepburn colliery, on the Tyne, on January 1, 1816.

The Stephenson Lamp

It is proper at this point to note the invention of George Stephenson, who is deserving of great credit for the valuable discoveries he made. He was a skillful enginer, and in 1812 obtained an appointment at the Killingworth colliery as erector of machinery. By many he was believed to be the first to discover and introduce a safety-lamp in mines, and the persistency of his friends aroused resentment amongst Davy's supporters. The dispute for first honors, while confined mostly to the friends of each, occasioned much bitterness. Smiles, in his "Life of George Stephenson," asks: "What chance had the unknown workman of Killingworth with so distinguished a competitor?"

From all the evidence presented, the facts appear to be as follows: In August, 1815, Stephenson requested Nicholas Wood, an official at Killingworth pit, to make him a drawing of a lamp. There is little doubt, therefore, that Stephenson was experimenting with lamps at the same time as Sir Humphrey. In October the lamp was being constructed for him by Newcastle tinsmiths, and the glass by a Northumberland glass house. The feed-air was admitted under the glass cylinder, through a tube ¼-inch in diameter, the amount being regulated by means of a slide. On testing this lamp on or about October 21st, it was found not satisfactory. Stephenson then took the lamp to another Newcastle tinsmith, and had it so reconstructed that there were three tubes to admit the air instead of one. He tried this second lamp November 9th, and the results were somewhat better than at the first trial.

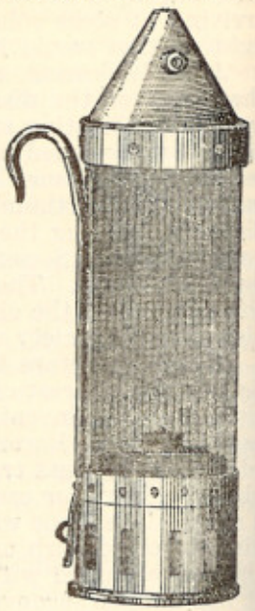


Fig. 4. Scotch Davy Lamp.

The announcement of Davy's lamp appeared on November 18th in the Newcastle "Chronicle." Two days later Stephenson went to Newcastle and had a drawing made of his third lamp. This differed from the preceding lamps in several ways, one of which was that the air was admitted under the glass by a double row of small perforations; but it did not have the wire-gauze. This lamp was tested on November 28th, 1815, at Killingworth pit with such gratifying results that it was pronounced "perfectly safe." Later, of course, it was shown that Stephenson's third lamp was not safe, as an explosive atmosphere could be readily fired with it, and the Brandlings, his most ardent supporters, preferred and used Davy lamps at their collieries; but to Stephenson must be given the credit for discovering one of the three great principles of the safety-lamp, namely, confining the burnt air in the upper portion of the lamp.

Stephenson later applied Davy's gauzes to his lamp, now called the Geordy, as did Clanny also to his lamp. The latter made further improvements by surrounding the flame with a glass cylinder instead of a glass window, as in his first lamp. The need of this was apparent to Clanny, because his experience as a "company" doctor had taught him that more accidents from falls occurred when the men were using steel wheels, owing to the faint illumination of the roof, than when they had the more abundant light of the candle. His introduction of the glass cylinder was condemned, however, by Davy as unsafe. This incident illustrates the different viewpoints of these two men, both striving for the same goal—the betterment of humanity.

Reception Given First Forms of Safety Lamps

The attitude of the miner toward the new Davy safety-lamp was, on the whole, favorable; but in some quarters the self-sufficient reason that their fathers and grandfathers had not used them, caused trouble. In some localities a superstitious fear was aroused. The gratification of mining men who learned to use the lamp, as well as the feeling of security inspired by them, is shown in the writings of John Buddle, here quoted:

"During the last 10 months it has been extensively employed in all the collieries under my inspection; and it gives me the highest pleasure to be able to state that during that time not the slightest accident by fire has occurred from its use, though

700 lamps are daily employed. In the parts of mines where fire-damp prevails the surveys and inspections are now carried on by the light of the lamp without apprehension of danger from explosion; for experience has shown us that with caution or keeping it in proper repair, it is absolutely safe, and for the truth of this I appeal to all my professional brethren who have had occasion to use it, without fear of contradiction. After finishing their day's work, the colliers bring their Davys to the lamp-keepers' cabin, who, unlocking them, takes the bottom into his own possession and allows the colliers to take the wire-gauze cylinders home for the purpose of cleaning them thoroughly. When the colliers return to their work the following morning the lamp-keeper, having replenished the lamp with oil and cotton, lights them and screws on their tops, and then examines them with the utmost care before he delivers them for use; but if the least injury or defect appears in the gauze, or any other part of a lamp, it is immediately set aside to be repaired, and the person to whom it belongs is supplied with a perfect one. After having dispatched the business of the morning the lamp-keeper occupies himself during the day in walking leisurely through amongst the workmen, carrying some spare lamps with him to replace such as may happen to be extinguished. It is scarcely necessary to observe that the lamp-keeper's cabin is always placed in a secure part of the mine, as near the workings as circumstances will permit."

When Sir Humphrey Davy perceived that his lamp was being misunderstood, and that men as eminent as John Buddle, through mistaken zeal, were, so to speak, placing a chip on their shoulder and defying their old enemy, fire-damp, to knock it off, he at once arranged a visit to the mines. Here he demonstrated to a body of interested men what he had learned in his laboratory experiments. At Lambton colliery gas was brought by a pipe from a blower in the shaft to the power house. The gas was then mixed with air and a lamp exposed to the blast. In a short time the gauze got red-hot, flame was passed, and an explosion resulted. Thesedemonstrations of the unsafety of a safety-lamp impressed his hearers. Davy then suggested that a tin shield be always used on the lamp when in high velocities, and that on entering a body of gas the lamp be withdrawn before heating and the flame extinguished, not by blowing out, but by dipping into a vessel of water or by drawing down the wick.

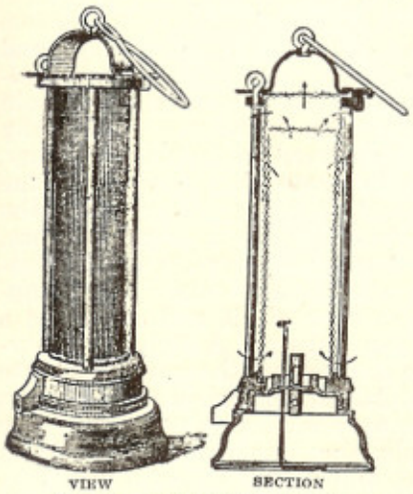


Fig. 5. Stephenson Lamp.

The general satisfaction with the Davy lamp, and also the Clanny and Stephenson lamps, which in their improved forms were as enthusiastically received as the Davy, was not lasting. The change from the insufficient candle to a lamp that gave off only 1/6 as much light created dissatisfaction amongst the men at the faces. Further, there was complaint that when the air current exceeded 6 feet per second the flame was puffed out. The official in charge of ventilation at one of the Earl of Durham's coal mines, in North England, had particular difficulty in keeping the lamp burning when passing through a narrow airway in which the velocity was about 2,400 feet per minute. He, therefore, ordered the lampman to make him a tin can of such diameter as would just allow the lamp to be placed therein, and directed that a glass pane be put on one side of the can, with a wire handle placed on top for carrying. When used in this form the official found that the flame was extinguished in an explosive mixture. When this peculiar behavior of the lamp became noised about it was duplicated in other collieries, and declared the safest arrangement known. The reason for extinguishing in gaseous mixtures was found to be the conflicting air currents in and about the lamp when the flame became elongated. On account of its appearance it was called the "Davy in a can," or "Tin can Davy." This contrivance was such a great step forward that there was no good reason why it should not be applied to the Clanny. Owing to the glass cylinder, however, the can was placed above it, and surrounded merely the gauze. On account of this change from the Davy can the name bonnet seemed to be more appropriate, and it was henceforth so-called.

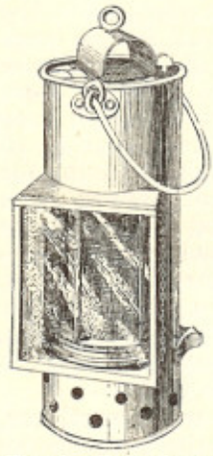


Fig. 6. Davy in a Can.

There can be no doubt that many explosions resulted from the failure of Davy lamps to withstand conditions frequently found in mines. In 1885 it was proved before a Royal Commission that a greater number of lives had been lost in English mines during the 18 years succeeding the introduction of the Davy lamp than in the 18 years immediately preceding the invention, and, on the strength of so much unfavorable testimony, it was finally condemned as unsafe. It is interesting to note that John Buddle retained his admiration for the Davy, and, as its champion, wrote that, throughout the 20 or more years during which he used them in his collieries, he never had an explosion.

The Clanny and Geordy lamps were held in equal distrust with the Davy, and it was everywhere apparent that the magical influence which safety-lamps were supposed to have over gas had been overestimated. True, they were the safest measure as yet devised, but they were so lacking in desirable features as to almost counterbalance the good realized from them. Therefore, the problem of mine lighting, which apparently had been solved, and solved in finality, in 1815, reappeared to be almost as vexatious and elusive as of old.

Improved Types of Safety Lamps

As was to be expected, the shortcomings of the Davy, Clanny and Stephenson lamps were eagerly seized upon by those of inventive mind. It was understood from the experience already gained that a lamp to be generally satisfactory—the ideal lamp,

as it were—must have all of the following commendable features:

1. Light of greater and more uniform intensity.
2. Freedom from smoke or soot.
3. Greater safety and sensitiveness in presence of fire damp.
4. Use a cheap oil.
5. Have a fool proof lock.
6. Have an internal lighting arrangement.

Many lamps, in consequence, made their appearance, and most of them an equally rapid disappearance. In all of them was to be found an attempt to correct one or more of the defects in the prevailing types. Many ingenious lamps were placed on the market, but as they did not embrace all of the desirable features, the majority were short lived. To show the zeal with which men sought for betterment, it is on record that in 15 years 12 lamps were invented in England having for their sole object the prevention of danger from opening the lamp, being so contrived that the flame was extinguished when the oil vessel was unscrewed. Hot air feed, enameled metal reflectors, electro-silvered gauze, sheet-iron cylinder inside gauze, talc covers, mica cylinder instead of glass, etc., were all experimented with, and as many as seven patents taken out on a single feature.

While most of these features were worthless, the lessons learned in conducting the experiments proved of great value and many excellent lamps, such as the Muesler, Marsaut, Ashworth-Hepplewhite, Gray, Morgan, Evan Thomas, Clifford, etc., etc., were a result. However, none of these lamps satisfactorily solved the question of lamp oil, nor had they any internal lighting arrangement. The commonly used vegetable oils, such as colza and rape, were objected to on account of their tendency to incrust the wick in burning. This greatly dimmed the light, and it often became necessary for the miners to open their lamps to clean the wick. This objectionable tendency of the oil was helped somewhat by the addition of petroleum, but while it increased the illumination it likewise increased the tendency of the flame to smoke, and it was not a complete success.

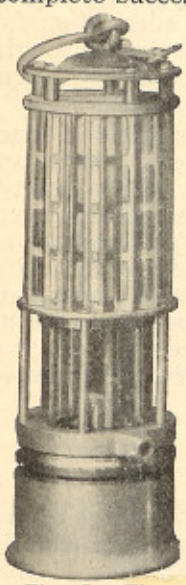


Fig. 7. The Wolf Lamp

Attention was directed to the locks with the view of making them more secure. It was known that in the mines the men would open their lamps to trim the wick and clean the globes, and to light their pipes, or to relight the lamp when extinguished. To obviate this dangerous practice, or rather the necessity for it, was required a lamp the lock of which could not be tampered with, a wick that did not smoke, and an arrangement for relighting the lamp when extinguished.

The Wolf lamp was undoubtedly the first to embrace all of these requirements. It is, in reality, an improvement on the Marsaut, which is in turn an improvement on the Clanny. It was first introduced into German coal mines in 1783, and at once attracted general attention in the coal districts of Europe. Two of the objectionable features in all preceding lamps had been overcome in the Wolf lamp, through the use of high volatile oil as the illuminant and a friction arrangement for the internal lighting of the lamp. Much unfavorable comment was made upon each of these innovations, especially upon the latter. It was thoroughly evident, however, by this time that there must be some arrangement provided for relighting lamps in mines without undue loss of time to the workmen and company.

Wolf lamps are used in nearly all German mines where safety-lamps are required, but never found much favor in England, being objected to on account of the use of high volatile oil, and because of the danger of placing in careless hands the privilege of relighting the lamp when extinguished.

The Wolf lamp, the illumination from which was far superior to that of other types of lamps, and which remedied much that was objectionable in safety-lamps, contributed greatly toward quieting the discontent wrought by the enforced use of safety-lamps. Indignation over their use had been steadily rising. Men complained principally about poor light and the danger from falls of roof which they were exposed to and could not detect. When the English Coal Mines Act of 1887 made the use of bonented lamps compulsory, the colliers were especially incensed, claiming that it would shut off their view of the top, and expressed themselves as more than willing to take their chances with an open light rather than with a bonneted safety.

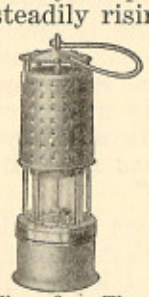


Fig. 8. The Koehler Lamp.

Increasing Dislike of Safety Lamps

There was also a suspicion gaining ground amongst the miners that safety-lamps were, in reality, not safe at all, and that many accidents could be attributed to the false confidence inspired by them. An incident occurred in Zwickau, Saxony, about 1865, which illustrated the distrust on the part of the miners. A lecturer had explained the principle of the safety-lamp to a large audience, and, to make his discourse perfectly clear, illustrated his remarks with experiments. He arranged a bell jar in plain view of all, and connected a rubber hose to a gas fixture. A lighted safety-lamp was set inside the jar and the gas turned into it. The lecturer explained that when sufficient gas had entered the jar an explosive mixture would be formed with the air, that the flame in the lamp would be elongated, and a long blue tip would be seen; then. on the addition of more gas, the whole interior of the gauzes would be filled with flame but, though the gauze might become red-hot, the flame could not possibly come to the outside and ignite the surrounding gas — all of which phenomena would be plainly visible through the transparent jar.

As was predicted, the lamp was filled with flame and the gauzes became red-hot; but the incorrigible flame communicated to the outside and ignited the gas. The lecturer was somewhat perplexed and repeated the experiment, with the same result. In his embarrassment he admitted his inability to explain this unexpected phenomena, but presumed that it must be due to an imperfection in putting the lamp together.

Previous to this lecture a disastrous accident had occurred in the fiery mines of Zwickau in spite of the use of safety-lamps. There were those who now used the results of the lecturer's demonstrations to explain the disaster. A test was then publicly made upon 60 lamps of various makes, and of those tested only two would retain the flame.

The incident at Zwickau made a great impression on the mining men of the United States. A call was made by mine officials that all safety-lamps be tested, in the belief that much good would result from knowing whether safety-lamps were actually as safe as believed to be. Furthermore, in the anthracite region of Pennsylvania, attention was directed to the successful use of the "eternal lamp" at Zwickau, in the hope that it would be experimented upon.

At additional distrust arose in the minds of some that, because of the use of safety-lamps, the importance of ventilation would be lost sight of. This is emphasized in the letter of William S. Jones, inspector of coal mines, found in Pennsylvania Inspector's Report of Anthracite Mines, 1878, as follows:

"The practice of working with the safety-lamp is wrong. It is not a safety-lamp, as the sad experience of thousands fully attests. * * * * Is it right, I ask in the name of suffering humanity, to work a colliery with hundreds of men and boys when the air of the whole mine is so near its explosive point as to necessitate the universal use of the safety-lamp? Are we not taking too great a risk when we compel our fellow men to work in air that will not permit the use of naked lights? Is the flimsy gauze of the safety-lamp not indefinitely too unsafe as a barrier or defense for precious lives against the deadly and relentless foe Is it not high time for mining engineers to take a radical step forward, and to demand that the safety-lamp, as a means to provide light to work by, shall be discarded at once and forever, and that all operators shall be compelled to provide a sufficient quantity of pure air to dilute the gas and make the atmosphere of the mine absolutely non-explosive?"

He goes on to recite the pitiful conditions in England, Wales and on the Continent, where the ventilation is so sluggish that the gauzes are constantly red-hot from the burning gas inside of them. This, he argues by way of illustration, because there is constantly given off 1,000 cubic feet per minute with only 15,000 cubic feet of air per minute to dilute it. He adds:

"The proper thing to do would be to double the quantity of air so as to make it perfectly safe to work with open lights. We would then have 30,000 cubic feet of air to 1,000 cubic feet of gas, and an explosion would be an utter impossibility. I may be alone in holding the opinion that the safety-lamp was never intended as a means to provide a light to work by, and that it is only adapted to the purpose of testing the condition of the atmosphere in mines as the works are extended; that it is adapted only to find the danger, and not to work in it, for it does not remove the danger, and cannot remove it. * * * * I further hold that the defense of the safety-lamp, as a proper means to light our coal mines, is an unmitigated disgrace to the boasted civilization and scientific intelligence of the nineteenth century."

It might be added that the Davy lamp is doubtless the one referred to by Inspector Jones, as the miners in the anthracite region obstinately clung to the Davy, for the only apparent reasons that it was light in weight and that their fathers had used it before them.

With the continuance of mine catastrophies grew the feeling that, great as has been the purpose and benefit of the oil safety-lamp as a minimizer of danger, it has, in the broader sense, never been a complete success from the day of its invention. With almost a century of experiments and improvements upon it, it has failed to provide absolute safety against fire-damp; it has failed to provide sufficient illumination; it has caused a large number of accidents through inability of the workmen to see dangerous conditions of roof and sides; it has bred discontent amongst men because of their capacity for labor being diminished, likewise among mine owners, due to the decreased efficiency of both day and contract labor. It has militated against the facility with which labor may be procured—the open light mine is always more attractive to labor than the oil safety-lamp mine. It is heavy, and the light cannot be directed where needed. As a means for detecting gas, however, the oil safety-lamp remains the standard for fire bosses' use.

Safety Lamp Gauzes

Heretofore three metals have been used for flame lamp gauzes—namely, steel, brass and copper. While each of these has the requisite qualities to some extent, none of them is an ideal gauze material. Copper gauzes lack mechanical strength, especially after they have been heated; brass and copper both have comparatively low melting points, so that before the gas ignition is reached the gauze metal is attacked and oxidized under the action of heat. Steel corrodes readily in damp atmospheres, and if the lamp stands unused under these conditions for some time, the gauzes become unfit for service. Tests of these three materials have shown that steel offers the highest degree of safety.*

From time to time it has been suggested that Monel metal should be a better gauze material than steel since gauzes made of this alloy should have all the good qualities that steel gauzes possess and, in addition, would not corrode appreciably in ordinary mine atmospheres. As a result of comparative tests made, conclusions have been drawn as follows:† The investigation showed that Monel metal is a very satisfactory material for flame lamp gauzes. Monel metal gauzes provide as great a degree of safety as do steel gauzes, and, in addition,

*Ilsley, L. C. and Hooker, A. B. Technical Paper 228, Bureau of Mines.

†Hooker, A. B. and Kearns, R. A. Report on Investigations, Bureau of Mines.

they do not corrode perceptibly in humid atmospheres. Monel metal gauzes maintained their shape and stiffness under the greatest heat to which they were subjected in gaseous mixtures equally as well as steel gauzes did; this, together with the fact that they do not corrode perceptibly in humid atmospheres, should assure a much longer life for Monel metal gauzes. It is believed that the use of Monel metal gauzes in flame safety lamps would be a step toward greater safety, and that their use should be encouraged.

The Electric Lamp

Many attempts to devise a reliable portable electric lamp for miners' use have been made by inventors, the first of which was probably in 1883. It was apparent that a practical lamp would have many advantages over the oil lamp.

But the first electric lamps all had two common defects; First, they were too heavy, and, second, they used a liquid electrolyte, which proved undesirable for several reasons. A portable lamp is necessarily composed of two parts, the battery which furnishes the current, and the bulb. The latter was quickly brought to a high perfection; the former became the troublesome element.

The Sussman electric lamp was the first to receive favorable notice in England, and was introduced about 1894. Instead of a liquid electrolyte, paper paste, impregnated with sulphuric acid was used, the total weight being 4¼ pounds. The illumination is twice that of a safety-lamp. Several thousand of these lamps were employed in English and Belgian collieries in 1904, the Bracquegnies colliery, Belgium, being reported as using 2,000 of them, and an English colliery 1,400. The cost of the lamp, including all repairs and renewals of the incandescent filament, was found to be ¼ cent per day of 12 hours. The life of the lamp was stated as five years. It is charged by connecting the battery to the wires of a dynamo for nine hours, the current for charging not exceeding eight amperes. At an English pit a record of the lamp's performance was kept for one month, and showed that, out of 504 lamps in use, an average of 96.73 per cent completed the shift, the remainder being rendered unusable from various causes.

The Neu-Catrice, another miners' lamp, was used at the Bruay collieries, France, and the Float lamp was introduced in Wales.

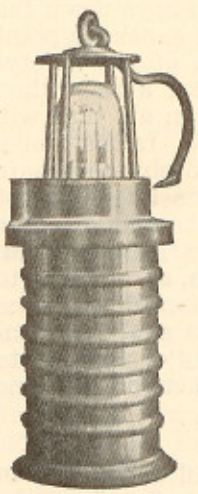
In the United States electricity as a lighting medium also received much attention. In 1896 it was suggested that arc lights be used in headings in place of incandescent lamps, and that the light be reflected so as to light the face. In 1901 the Pennsylvania legislature seriously considered making it compulsory for all mine owners to electrically light the entire inside of the mine.

Electric lamps were placed on the market in 1902, but, on account of the objections common to all the earlier types, were not favorably received. Early types were experimented with by the Philadelphia & Reading Coal & Iron Company, the Lehigh Coal & Navigation Company, and the Lehigh Valley Coal Company in the East, and the Colorado Fuel & Iron Company in the West.

None of the early experimental lamps proved successful. One of the principal difficulties lay in the inefficient carbon filament bulb which required a storage battery of too considerable a weight to be carried on the body with comfort. It was also soon demonstrated that the leakage of acid was a serious problem, as it was impossible to prevent the acid from creeping out around the cell connections and vent plug when used in a stooping position or running. It attacked every metallic part of the battery with which it came in contact, destroyed the men's clothing and even burned the bodies of the workmen.

In 1909 the Tungsten miniature lamps were first placed on the market in America for limited or special commercial uses. The efficiency, or watts per candle, was about three to four times better than the carbon lamp. The effect of this improvement was to stimulate the search for a battery of sufficient lightness to enable it to be worn about the body.

The next two years were given to testing and developing lamps under actual working conditions and in trying to overcome the obstacles usually associated with the introduction of a novelty. Fully a dozen makers devised lamps during this period, the foremost cap lamp being the Hirsch, while the Ceag was the best known of the hand type.



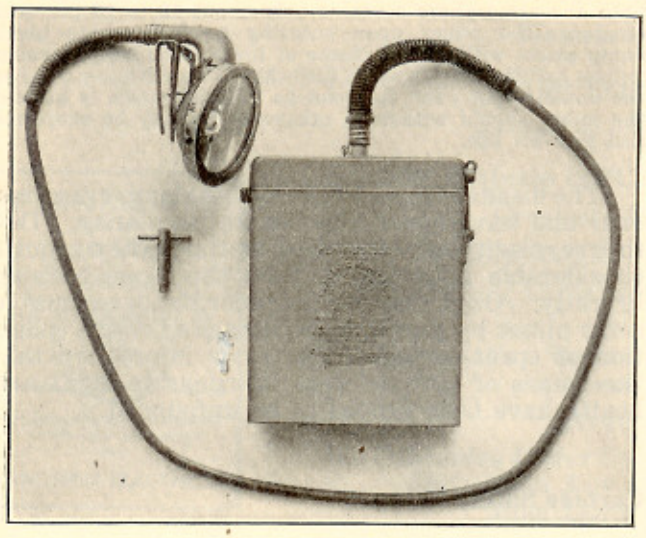
Miner's Hand Lamp

In March 1911 Thomas Edison became interested in the development of a practical miner's lamp and in May 1912 the first lamps made by the Edison Storage Battery Company were tried out in the mines of the Philadelphia and Reading Coal and Iron Company. Concurrently the Wico lamp was introduced and tried out by the same company.

During the latter part of 1913 the Bureau of Mines, through H. H. Clark, became interested in the electric cap lamp, and after a personal tour of inspection and investigation at the Reading Company's mines, took up the work with the view of standardizing its various features. Their chief concern was safety, thus making the lamp acceptable for general mine use. All available makes were studied and tested, and as a result a schedule of official tests was prepared which were used in establishing a list of permissible safety lamps for use in mining. This step was the means of bringing home to the manufacturers the realization that the electric cap lamp was here to stay and created not a little competition to produce the best lamp possible.

Today we find the cap lamp comprising a nonspillable battery mechanically protected by an

aluminum or steel case having the cover locked and arranged to be carried on a belt, a special twin flexible conductor conveying the current from the bat-



Miner's Cap Lamp.

tery to the lamp on the cap, encased for a short distance at both ends by flexible steel armor, serving as an anchor and preventing sharp bending. The lamp consists of a parabolic reflector equipped with safety features, in which is mounted a tungsten lamp, the opening supporting a glass lens cushioned on gaskets held in place by a cap or spring, and provided with a hook to fit into the miner's cap.

When wearing the outfit a man can put himself in any position without restraint. It does not interfere with free motion of the body in any direction. He can use all tools and perform any desired work with as much freedom as when wearing the oil cap lamp.

Special combination charging stations are provided with facilities for charging, cleaning and filling both the electric lamps and the oil safety lamps.

The electric cap lamp has fully passed the development stage though improvements will doubtless continue, thus bringing it to a higher degree of perfection as the requirements are better understood and appreciated by the users.*

Advantages of Electric Cap Lamps

The advantages to be gained in the use of the electric cap lamp, approved by the United States Bureau of Mines as "permissible" for use in gaseous mines, are enumerated by the Bureau of Mines, as follows:

(1) It reduces, to the lowest possible, the hazard of gas explosions.

(2) It reduces the danger of getting burned by lighting gas which may accumulate from a feeder found by drilling a hole.

(3) It reduces the possibility of a serious dust explosion which may easily start by an open light igniting a little pocket of gas.

(4) It reduces the great danger of mine fires which are so frequent in mines, due to setting off a gas feeer at the face of the advancing narrow work in nearly all mines.

(5) It reduces accidents from handling explosives in the magazine, also during transportation and preparing shots at the face, etc.

(6) It gives a much greater chance for a miner to escape for his life after a local explosion or through smoke from a fire due to having a light to travel by.

(7) Reduces accident to drivers, motormen, rope-riders and shotfirers, as the electric light is more dependable against any velocity of the air-current, windy shots, etc.

The electric hand lamp differs from the cap lamp only in detail. The battery and bulb are brought together into one unit and thus the cord is eliminated. As with the oil safety lamp it is carried by means of a bale and when at the working face can be hung on a post conveniently close to the workings. While the weight of the hand lamp is frequently cited as an objection it must be borne in mind that this weight is not continually carried as is the case with the cap lamp.

Lighting of Non-Gaseous Mines

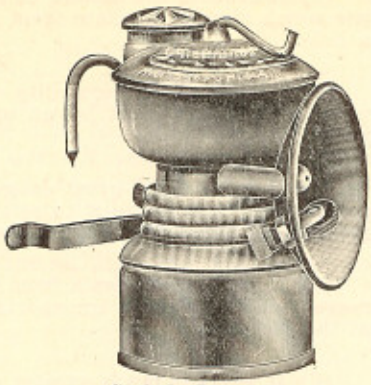
The lighting of non-gaseous mines has never presented any great difficulties; but, as with the users of safety-lamps, men obliged to labor underground have ever been in search of better light. The greatest objection to open oil lights has been the great amount of smoke or soot given off. The oils used in the anthracite regions in the earlier days were sperm oil, whale oil, seal oil, cotton-seed oil and lard oil. These afforded good light, but it was soon discovered that the addition of kerosene increased the illumination, and the miners dubbed this self-made mixture "the World's Light."

Manufacturers were quick to notice the demand for an adulterated oil, and at once placed such oils on the market under fantastic names, such as "Electric Miner's Oil," "New Era," "Wildfire Jack," etc., all of which were labelled "saf " "non-explosive," "economical," etc. Drivers began the use of "black strap," which gave off an immense amount of smoke, or else burned nothing but kerosene, which possessed an additional advantage in that it seldom blew out and left them in the dark.

The attention of mine inspectors was early called to these pernicious practices, and the use of adulterated oils finally became so great a menace to life and health in Pennsylvania, and in all coal mining states, that legislatures have passed bills defining the quality of miners' oil to be used. In spite of this, however, violations of the law have

*For a very interesting account of the development of the electric cap lamp in America, see paper by J. T. Jennings, "Historical Development of the Miners' Electric Safety Cap Lamp," Proceedings Coal Mining Institute of America, 1916, and which has been drawn upon in this article.

been frequent, and the prevailing dissatisfaction has resulted in the appearance and use of the acetylene lamp.



Carbide Lamp.

The Acetylene Lamp

Acetylene gas was accidentally discovered in 1836 by Professor E. Davy, of Dublin; but not until 1892 was it produced at a commercially cheap rate. It was likewise accidentally discovered by H. Moissay, who, while conducting experiments with an electric furnace, noticed that the wall of the furnace, consisting of lime, fused into a liquid state at 3,000 degrees, Centigrade, and that a combination between it and the carbon of an electrode produced calcium carbide. T. L. Wilson, by accident also, and while experimenting with an electric furnace, discovered a method which resulted in the manufacture of calcium carbide on a large scale.

Carbide lamps are too well known to require description. In the short space of twenty years their use has extended into all states and countries, largely displacing the oil cap lamp of the coal miner and the candle of the metal miner. As a means for lighting in non-gaseous mines, the carbide lamp has the following advantages over the oil or candle light:

1. Produces no carbon monoxide.

2. Produces 1/10 the amount of carbon dioxide, and 1/13 the amount of water vapor that an equal amount of candles would produce.

3. Consumes only 1/5 as much oxygen.

4. Gives a 4 to 6-candlepower light.

5. Will serve, if properly used, as an indicator of black damp. It has been fully proved that the flame of the carbide lamp does not require as much oxygen for the support of combustion as is needed for the flame of an oil lamp or a candle. The flame of an oil-burning lamp goes out when the atmosphere surrounding it contains 17 or 17½ per cent of oxygen, whereas an acetylene flame does not go out until the atmosphere contains only about 12 to 13 per cent oxygen. The miner upon entering a place where black damp exists will find the flame of his carbide lamp burning yellow and turning upward, also that if he advances farther the flame is put out. As soon as this indication is noticed the miner should withdraw, otherwise he may be overcome and lose his life.

The disadvantages of the carbide lamp are minor ones and have never affected its popularity. Due to irregularity of water feed at times they require considerable attention to keep the flame burning brightly. Objection to the odor is overcome in some mines by providing receptacles for the collection of spent carbide. The early impression that the fumes of carbide were injurious to sight and health have been proved to be unfounded.

Carbide Safety Lamps

Carbide was naturally siezed upon as a substitute for oil in safety-lamps, and safe and efficient acetylene safety-lamps have been introduced. The flame is 10 candlepower. With one per cent of methane, a clear, blue cap is shown, which increases as the percentage of gas is increased until, at 3¾ per cent, there is a well-defined cone.

The objections to this lamp have been stated as:

First—The increased weight.

Second—It needs additional carbide and water to burn through a shift.

Third—It gets hot when stationary.

Fourth—It requires more attention at the hands of the user than an oil lamp.

In intelligent hands this lamp can be used successfully and an excellent light is afforded, which amply compensates the disadvantages.

CONCORDIA ELECTRIC COMPANY

369 Union Trust Bldg., PITTSBURGH, PA.

Manufacturers of the

"CEAG" Electric Safety Mine Lamp

PERMISSIBLE
PORTABLE
ELECTRIC MINE LAMP
APPROVAL No. 19.
Issued for safety and for practicability and efficiency in general service to the
CONCORDIA ELECTRIC CO.

Superior Features in "CEAG" Cap and Hand Lamps

Greatest Volume of Light

Dry Electrolyte Battery—No Leakage

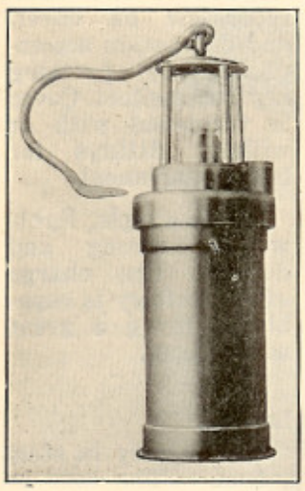
Simplicity of Construction with Fewest Number of Parts

All Repairs Can Be Made By Handy Man in Your Lamp House

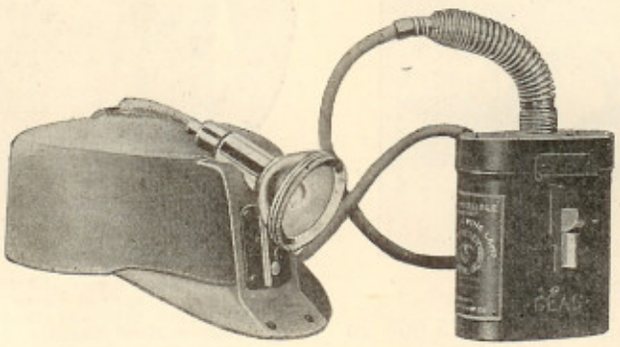
Magnetic Lock

We Guarantee Lower Cost of Maintenance Per Lamp Shift Than Any Other Electric Safety Mine Lamp on the Market

PERMISSIBLE
ELECTRIC HAND LAMP
APPROVAL No. 1000
ISSUED TO THE
CONCORDIA ELECTRIC CO.
Approved for safety and adequacy for the services designated:
1 Hand lamp service - When equipped with white glass dome.
2 Trip lamp service - When equipped with ruby glass dome and when used with special iron clamp furnished by the manufacturer

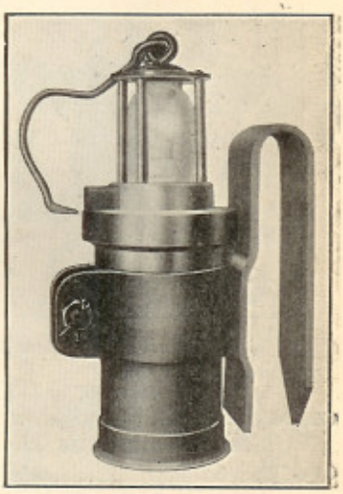


"CEAG" RMC Hand Lamp All Metal Dry Electrolyte Lamp



"CEAG" RM-6 Cap Lamp

There Are More "CEAG" Electric Safety Lamps in Use Throughout the World Than All Other Makes Combined

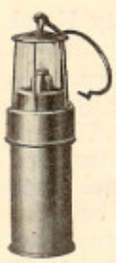


"CEAG" RMCT Trip Lamp with ruby glass dome and hook for attaching to mine car All Metal Dry Electrolyte Lamp

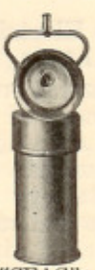
The specially designed electrodes for use of our solidified electrolyte require no separators and there can be no buckling of plates. Our solidified electrolyte absolutely prevents corrosion of terminals and leakage, which so frequently causes injury to the clothing or person of the user of liquid electrolyte lamps. The solidified electrolyte maintains a complete contact with the electrodes resulting in a constant uniform light regardless of the position of the battery.

"CEAG" lamps can be completely assembled and disassembled and all repairs made by your own lamp man at the mine, thereby saving the cost and trouble of having to send batteries to the factory for repairs.

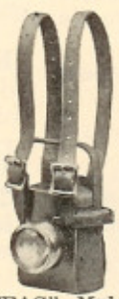
"CEAG" Locomotive Headlight LN-1 (Front View)



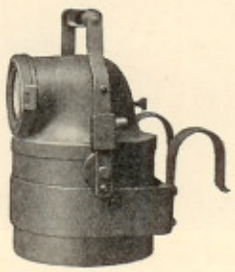
"CEAG" Inspector's Lamp GM (all brass)



"CEAG" Inspector's Lamp GMS with Reflector attachment (all brass)



"CEAG" Mule Lamp MU with Leather straps to be attached to the collar of the mule



"CEAG" Locomotive Headlight LN-1 (Side View)

"CEAG" Watchman's Lamp W

INSTALLATIONS ON RENTAL CONTRACT OR OUTRIGHT SALE.
WRITE FOR CATALOGUE.

Edison Storage Battery Company

Factory and Main Office

316 LAKESIDE AVENUE, ORANGE, N. J.

Manufacturers of the

Edison Electric Safety Mine Lamp

Distributors in

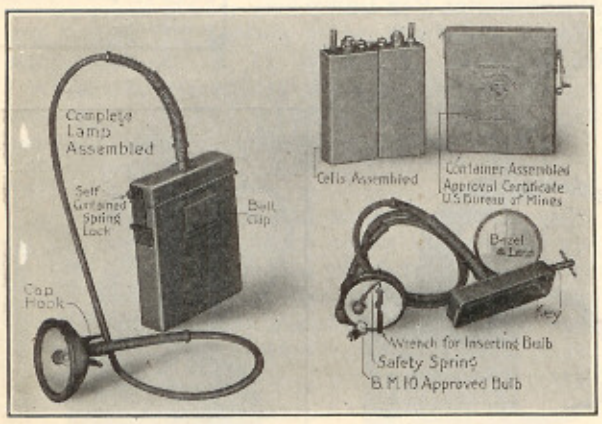
NEW YORK, ATLANTA, NEW ORLEANS, BOSTON, CLEVELAND, DETROIT, PHILADELPHIA, PITTSBURGH, WASHINGTON, CHICAGO, ST. LOUIS, MONTREAL, SAN FRANCISCO, SEATTLE, LOS ANGELES

General Distributors

Mine Safety Appliances Co., Pittsburgh, Pa.

The Edison Electric Safety Mine Lamp

The Edison Mine Lamp is a **permissible** portable Electric Mine Lamp. It is the first to be approved by the Bureau of Mines for Safety, Practicability, Efficiency and General Durability in Mine Service.



Unassembled View Edison Mine Lamp

Standard in over 1,000 mines, over 175,000 in use in Metal and Coal Mines of the United States.

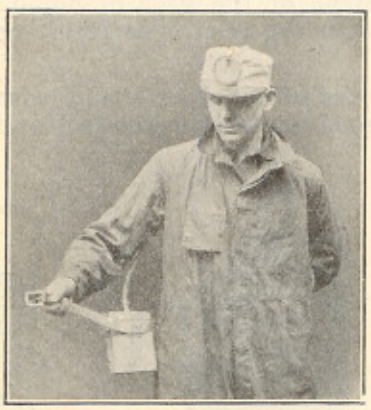
Older installations show uninterrupted service over five years.

Burns 12 hours without recharge.

Fire Protection for your valuable operation.

Method of Attaching

The miner straps the battery case to his back by an ordinary belt. The lamp is attached to the



Method of Attaching

leather support in his cap, leaving his arms entirely free of lamp, cord and battery case.

Described in Bulletin No. 300.

See Page 695 for details of the Edison Battery.

Edison Shot-Firing Battery. Showing how special cover for shot-firing is attached to regular Edison Mine Lamp.

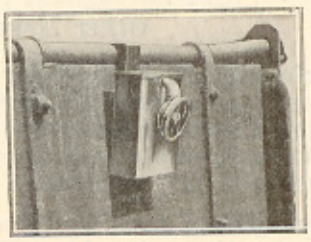
The Edison Electric Shot-Firing Battery

Showing cover for M-8 Mine Lamp Battery arranged for shot-firing. Shot-firing cable is attached to a key furnished with cover. Key is then inserted in receptacle on cover, and detonation accomplished by pressing key into contact. Cover is furnished with or without fittings for lamp attachment.

It is simple, lightweight, strong and durable. One charge of the battery is capable of firing a great many shots.

Edison Electric Safety Trip Lamp

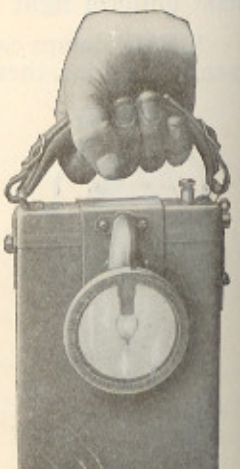
Consists of M-8 (Mine Lamp) Battery in steel case with special cover and lens. The case is provided with hook for attaching to mine car as "head" or "tail" light. This device is approved by the Workmen's Compensation Insurance Inspectors.



Edison Trip Lamp—Hooks Over Either End of the Car

Edison Electric Safety Hand Lamp

Illustration shows arrangement of Edison Safety Mine Lamp as a hand lamp. This consists of a standard M-8 Battery in steel case with special cover. The lamp is attached directly to cover and the cover provided with bails for attaching leather handle. Largely used as Inspector's, Official's and Visitor's lamp.



Electric ety Hand p

KOEHLER MFG. COMPANY, INC

Factory and Main Office

MARLBORO, MASS., U S A

BRANCH OFFICES

1634 Jefferson Avenue, Scranton, Pa. 530 Fernando Street, Pittsburgh, Pa.

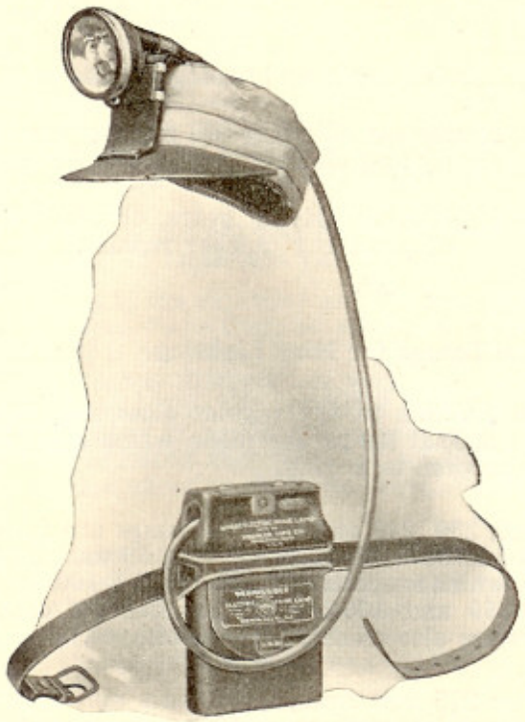
Wheat Electric Mine Lamp

"WHEAT" FOR LIGHT "KOEHLER" FOR TESTING

The Important Features

Two Bulbs in Headpiece—A bulb always in reserve. Eliminates lost time and accidents through being "left in the dark."

More Lighting Power—The bulb gives a clear white light and will burn from 12 to 16 hours on one charge.



U. S. Bureau of Mines Approval No. 17

Headpiece Always Sealed—The headpiece is provided with a locking and sealing device which prevents its being tampered with, and keeps out dirt and can be quickly opened or sealed by the lamp attendant.

Absolutely Safe—Should the lighted bulb be broken its electric current is instantly and automatically disconnected.

Lamp Burns with Battery in Any Position—The battery casing is so constructed that it can be carried in any position without leakage, or affecting the lighting capacity of the bulb.

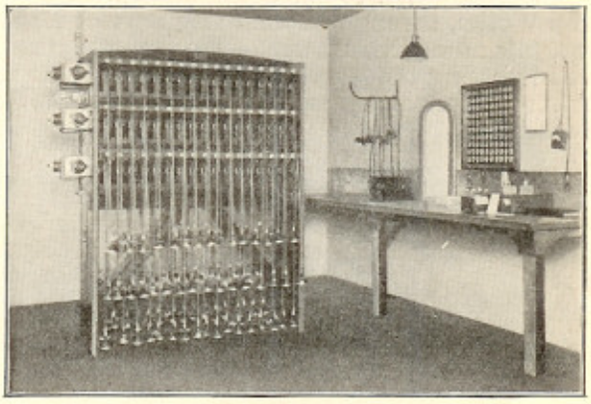
Easy Charging—The Wheat Electric Mine Lamp **does not** have to be taken apart for charging, but goes into the charging rack completely assembled.

Durability—The headpiece and battery casings are made of a special vulcanized material that is as strong and light as cast aluminum, and is absolutely unaffected by acid fumes or water.

Lamp Cord Cannot Bend Short—An improved cord connection, without springs, prevents short bending and breakage at entrance to battery case—gives greater security and longer life to lamp cords.

Greater Comfort to Wearer—The two belt connections to the battery case are as far apart as possible, thus greatly increasing the wearer's comfort.

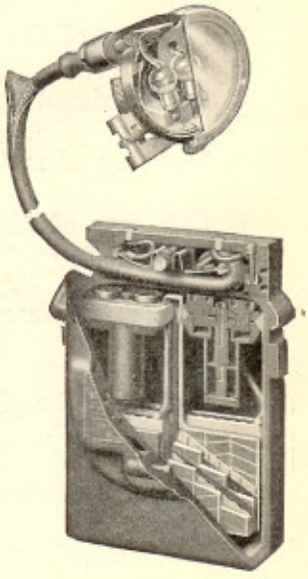
Superior Construction—All parts are specially designed for convenient removal and assembling. This saves time and labor, and insures perfect condition of lamps at all times.



Layout of Lamp House

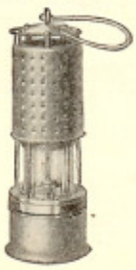
Repairs

All replacements and repairs on this lamp can be made in your lamphouse by your lampmen. This advantage is recognized by all our users.



Koehler Flame Safety Lamp

U. S. Bureau of Mines Approval No. 201.



The ideal lamp in testing for gas.

Made in steel, brass and aluminum, either magnetic or key lock, with round or flat wick.

ASK FOR CATALOG AND PRICE LISTS

EDISON LAMP WORKS

OF GENERAL ELECTRIC COMPANY

Harrison, N. J.

Lamps and Lighting Recommendations

The Edison Lamp Works of the General Electric Company make all sizes and types of MAZDA lamps; complete stocks are carried in every part of the country.

But, in addition to supplying lamps, the Edison Lamp Works, through its **Lighting Service Department,** fills an additional need—by rendering assistance in putting the lamps to work properly, so that maximum production may be obtained at minimum expense.

Our trained engineers, who have studied mine lighting requirements, can help you on these problems:

1. The prevention of lamp stealing.
2. Reduction of lamp breakage.
3. Lighting of the headings and faces.
4. Switch signal lighting.
5. Lighting of motor repair pits.
6. Efficiency of 110, 220 and 500 volt lighting systems.
7. Where to use reflectors; proper types and sizes.
8. Lighting the foot of the shaft without shadows.
9. Proper lamps for miners' caps.
10. Locomotive headlight lamps.
11. Eliminating lamp breakage in the breaker.
12. Increasing efficiency of picking bands and picking chutes through proper lighting.
13. Lighting of driving gears, etc., as a means of providing quicker repairs.

Special Lamps for Mine Lighting

In addition to the regular sizes and types of lamps special lamps are made which are particularly adapted to mining.

220, 230, 240 and 250 volt lamps are furnished in 25 and 50 watt sizes, and in a 50 watt mill type lamp, which is specially constructed. 100, 200, 300, 500, 750 and 1000 watt gas-filled (MAZDA C) lamps are also made in these voltages.

For 275 volt lines, a 50 watt mill type lamp is offered as well as a 100 watt vacuum type (MAZDA B) lamp.

525, 550, 575, 600, 625 and 650 volt lamps can be obtained in either 23, 36, 56 or 94 watt sizes. For headlights at these voltages, there is a special concentrated filament lamp which can be obtained in either 23, 36, 46, 56 or 96 watt sizes.

Free Lighting Recommendations

The Lighting Service Department will make, free of charge, lighting layouts, recommendations and specifications and furnish all data and information on any lighting problem you may have. A request addressed to them at the main office or at any of our branch offices throughout the United States will receive prompt attention.

NATIONAL LAMP WORKS

OF GENERAL ELECTRIC COMPANY

Nela Park Cleveland, O.

National MAZDA Lamps

NATIONAL MAZDA LAMPS FOR ELECTRIC CAP OUTFITS

According to statistics collected and published by the United States Bureau of Mines, a very great number of the fatalities due to gas and coal dust explosions in coal mines are directly traceable to the use of defective safety lamps and open lights. The elimination of this explosion or fire hazard has been for a number of years the subject of much scientific research, in which the development of outfits using incandescent electric lamps has played and is playing an important part.

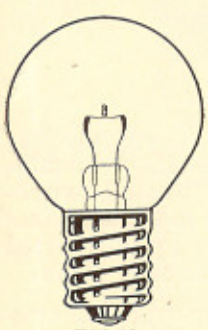
In addition to the explosion and fire hazard dangers of the open flame there is another element of danger which it provides. The flicker of the open flame lamp makes illumination very poor and in combination with the low intensity and the constrained positions in which the miners work, this flicker is frequently the cause of nystagmus, a nervous disease affecting the eyes, prevalent among miners.

The introduction of the portable electric safety lamp outfit made available for miners and others a source of illumination characterized by absolute safety, good distribution of light, absence of flicker and rapid change of intensity, and durability at a moderate cost.

Our Engineering Department has co-operated with the United States Bureau of Mines and the manufacturers of portable electric safety lamp outfits in the development of the principal outfits and lamps to meet the Bureau of Mines' rigid specifications.

Disregarding the superior efficiency of the electric cap lamp, all gaseous mines should have the portable electric outfit. It is dangerous to have unprotected flame lamps in even non-gaseous mines due to fire hazards as has been proved in numerous mine disasters. You can always be on the safe side by using recommended electric cap lamps equipped with National MAZDA Lamps approved by the Bureau of Mines.

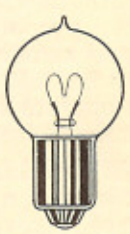
The Electric Cap Lamp Gives the Best Possible Illumination With the Utmost Safety.



BM-18 the New Model "E" Edison Electric Cap Lamp.

NATIONAL MAZDA LAMPS FOR APPROVED OUTFITS

Outfit	Approved Symbol	Volts	Amperes	Bulb	Base	Unit Pkg. Qty.
Edison (old)	BM-10	2.60	0.37	G-5	1829	100
Wico	BM-14	1.90	0.65	G-6	1001 D. C Bay	100
Wheat	BM-17	4.00	0.50	G-5	1841	100
Edison (new)	BM-18	2.50	1.10	S-8	Candelabra Screw	100



BM-17 For the Wheat Electric Cap Lamp.

American Safety Lamp & Mine Supply Co.

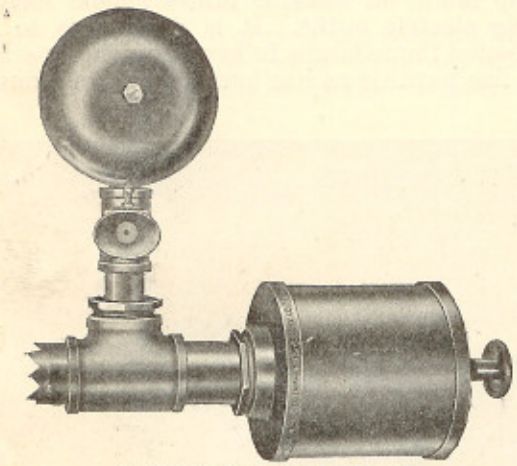
1327 Capouse Ave., SCRANTON, PA.

Safety Lamps — Signals

Products

Miners' Safety Lamps; Miners' Acetylene Lamps; Valves and Cocks; Grease and Oil Cups; Electrical Fittings; Pneumatic Signals; Trip Alarms; Brass, Bronze and Iron Castings; Grille Work; Machinery Guards; Railings; Window Guards; Brake Shoes; Trolley Wheels; Trolley Harps; Signal Switches; Surveyor's Tape Reels; U-tube Water Gauges; Locomotive Whistles; Journal Brasses; Boiler Water Feed Regulators; Automatic Cylinder Drainers.

Pneumatic Signals



American Pneumatic Signal. Style E-309.

These signals furnish the safest and most reliable system of communication known for underground work.

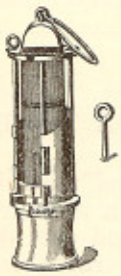
As they are made of brass and with no electrical connections whatever, there is no danger from electric sparking, etc. The U. S. Bureau of Mines reports as a result of its tests that the ordinary type of electric mine telephone is not safe in gaseous atmosphere. In contrast to this, with the American Pneumatic Signal system safety is paramount and certain.

Another very desirable feature is reliability. When properly installed, the American Pneumatic Signal remains continuously in working order. It may be left untouched for days or months, and yet operate successfully at the first impulse of the piston.

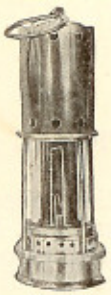
Material falling down the shaft, or rock falls cannot cause a false signal, as frequently occurs where wires are used for mechanical signalling. There are no wires to break or become short circuited nor is the line readily damaged by fire or water.

Engineers desiring data on installation, etc., should send for our Bulletin No. 19, stating the number of stations and distances involved.

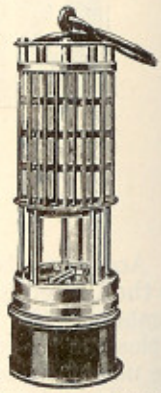
Miners' Safety Lamps



No. 6 Davy Lamp.



No. 31 Deputy Marsaut.

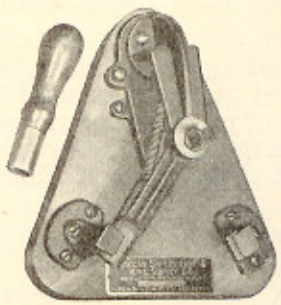


1-B Safety Lamp

Although but three models of lamps are illustrated on this page, our factory produces a number of different models to suit conditions in different localities. The No. 6 Davy shown is of large gauze area, and extremely sensitive. It is made in brass or aluminum and widely used for testing purposes. The Deputy Marsaut is an official's testing lamp; often used with the Beard-Mackie indicator, which gives a fixed standard for comparative tests.

The American 1-B Type Safety Lamp is very sensitive to gas, indicating plainly as low as ¾ of 1% with the luminous flame. With the non-luminous flame as low as ½ of 1% of gas may be detected, and ¾ of 1% shows a distinct gas cap.

Electric Specialties



Three Point Signal Switch

The signal switch illustrated above is a valuable indicator of cars which have passed beyond switching points. When properly installed in locked boxes these switches may be turned only by authorized operators to whom turning keys have been given.

Other electric specialties are our overhead trolley frogs, cable splicers, buss bar and grid terminals, etc. We also entertain orders for special fixtures to customers samples. Write us.

Wolf Safety Lamp Company of America, Inc.

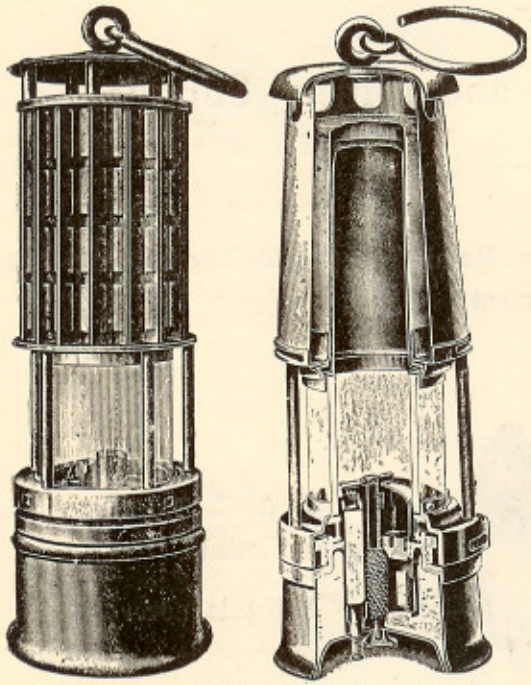
220-224 Taaffe Place, BROOKLYN, N. Y.

Miners' Safety Lamps

Products Made in U. S. A.

Wolf Miners' Safety Lamps Burning Naphtha, Vegetable Oil and Acetylene. Wolf's Open Carbide Lamps for Hand, Cap and Trip. Tools and Accessories for all types of lamps. Newton Oiling Device for Mine Car Wheels.

Wolf's Standard Safety Lamps



No. 100 with magnetic lock No. 201
No. 131 with key lock No. 232

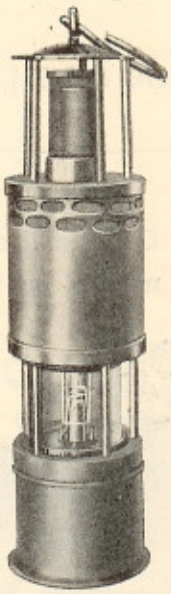
Standard Wolf Safety Lamps are furnished in all Aluminum or in Steel with brass fittings.

The No. 100 and No. 131 types can be equipped with round or flat burner.

The No. 201 and 232 types with flat burner only.

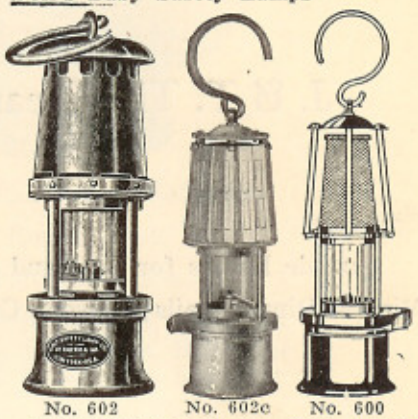
Our No. 100 Lamp is approved by the United States Bureau of Mines, their approval No. 204.

Wolf-Fleissner Singing Safety Lamps



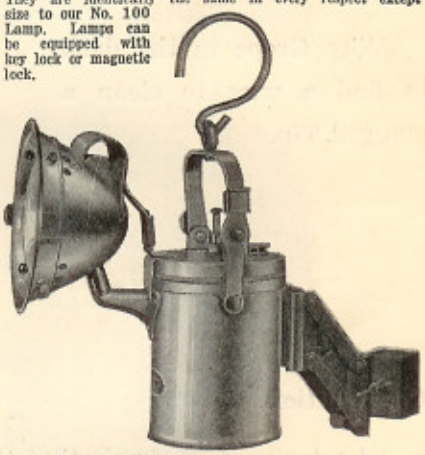
Up to recently it was only possible to detect mine gas by the action of the naphtha flame, visible to the eyes only. The Wolf-Fleissner Lamp will not only indicate to the eye methane and other explosive gas if 1% and up is present in the mine air, but also as soon as this Lamp is surrounded by explosive gas a sound will be heard which increases in strength whenever the percentage of gas present increases. This very efficient attachment will also be embodied at a very early date in the Standard No. 100 and 131 Lamps. Please write for further information.

Wolf's Baby Safety Lamps



No. 602 No. 602c No. 600

These Lamps are very light in weight (No. 600 weighs 12 oz. and is 7¼ inches high). They are made in Aluminum only with metal spark or paraffin igniter, are very sensitive to gas and equipped with double gauzes. They are identically the same in every respect except size to our No. 100 Lamp. Lamps can be equipped with key lock or magnetic lock.

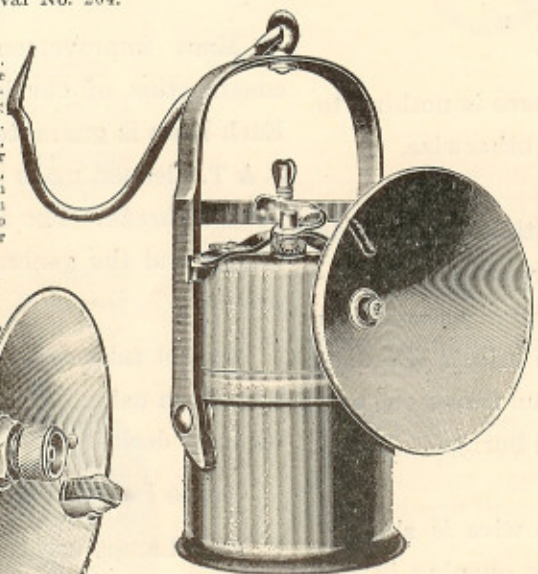


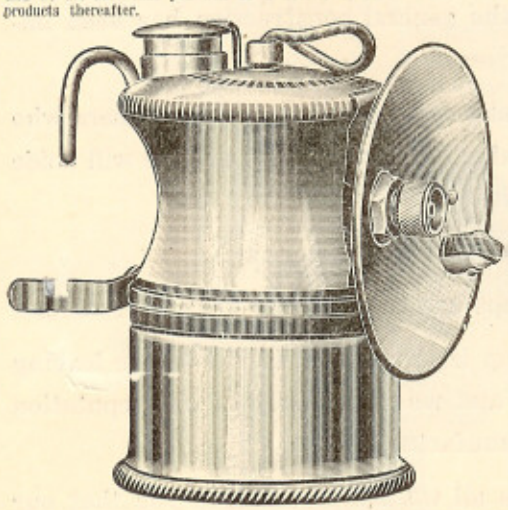
Trip Light for Non-Gaseous Mines

Persistent demand for a serviceable and fool-proof Trip Light has induced us to construct this Lamp. Lamp can be used on front or rear end of trip, equipping same with either a strong white or red lens. Attachment to fasten Lamp to car is made in such a way that the spring will take off any jars of the trip. Lamp will burn a full shift and the motor man if necessary can remove the Lamp immediately from the attachment, using same as Hand Lamp in case of trouble. Lamp is steel tinned.

Wolf Carbide Cap Lamp No. 911C.

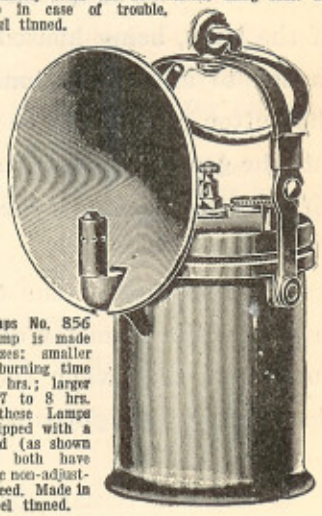
The latest improved Wolf Cap Lamp, shown below, is the product of practical mining men who are familiar with all lamps on the market. It is undoubtedly today the strongest Cap Lamp made, yet its weight is no more than 5½ ounces, uncharged. If you are looking for a lamp that will give service, a burner which is practically windproof, a reflector which is strongly constructed and cannot be lost, with an extra good lighter and other features which appeal to the man who has used other Cap Lamps on the market, then send us a trial order for a Lamp and we are sure that you will be a booster of our products thereafter.





Open Carbide Lamp No. 905a

This Lamp is finished in steel tinned, with a sharp or plain hook and very similar to the No. 856, except it is equipped with a parabolic reflector protecting flame against dripping water. The burning time is 5 to 6 hours. Weight 1¾ lbs. Height 8½ inches. This lamp is equipped with lighter.



Carbide Lamps No. 856

This Lamp is made in two sizes: smaller one has a burning time of 5 to 6 hrs.; larger size burns 7 to 8 hrs. Either of these Lamps may be equipped with a reflector hood (as shown above) and both have the automatic non-adjustable water-feed. Made in brass or steel tinned.

Wolf Acetylene Safety Lamp—A Suitable Lamp For Mine Rescue Work

Newton Oiling Device For Mine Car Wheels **Write for Complete Literature and Prices**

THE GRIER BROTHERS COMPANY

ESTABLISHED 1839

PITTSBURGH, PA.

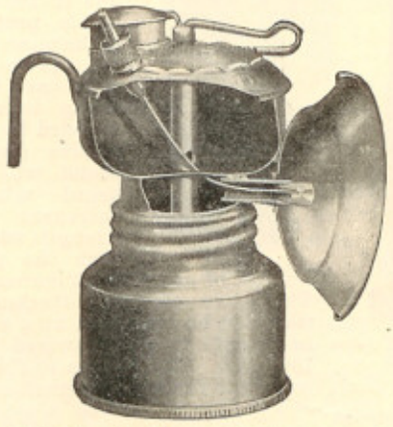
Manufacturers of

J. & T. Tip Cleaner Carbide Lamps and Miners' Supplies

Products

Carbide Lamps for Coal and Metal Miners; Carbide Flasks; Metal Tips; Carbide Lamp Repair Kits; Miners' Dinner Pails; Powder Cans and other miners' equipment.

Why Grope in the dark to find a wire to clean a plugged Tip.



Cut Showing How J. & T. Cleaners Are Installed in Grier Lamps

J. & T. Tip Cleaner is always ready.

Light is never out.

Saves time and money.

Construction

The device is so simple that there is nothing to get out of order from corrosion or otherwise.

A small wire of special composition works inside of the lamp, being housed in a brass tube and attached to a push button. A slight pressure on the button on the outside of lamp injects the wire into the gas orifice in the burner and forces out any dirt or other matter lodged in the burner.

The diameter of the cleaning wire is slightly less than the diameter of the gas opening in the burner, so that when the wire is projected into the opening the light will not be extinguished.

It is not necessary to remove the lamp from the cap.

Many improvements have been made in the construction of our lamps during the past year. Each lamp is guaranteed to give satisfaction. The J. & T. Cleaner, made of heavy special wire, will not bend or break. The felt holders are of a different design and the general construction has been improved.

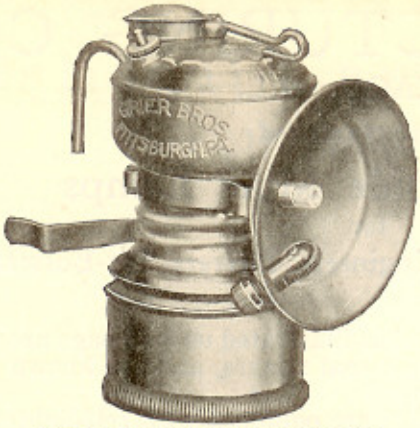
Do not take our word, but ask the miners who have been using our latest lamps and we will abide by their decision.

Three Points to remember.

Our Lamps are made better than ever before.

Each lamp is thoroughly tested before leaving our factory and we stand back of our reputation as Lamp Manufacturers.

A trial is all we ask to convince you that our lamps have no equal.



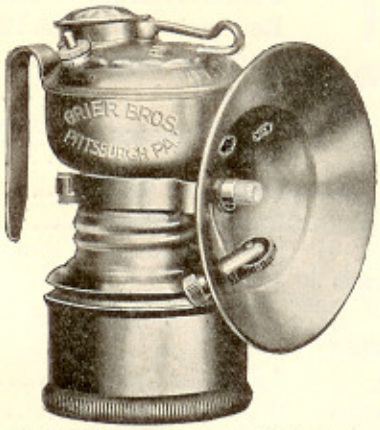
With Detachable Reflector
Round Hook

Polished Brass

No. 96C—2¼ in. Reflector
No. 87C—2½ in. Reflector
No. 98C—3 in. Reflector

Polished Nickel

No. 106C—2¼ in. Reflector
No. 117C—2½ in. Reflector
No. 119C—3 in. Reflector



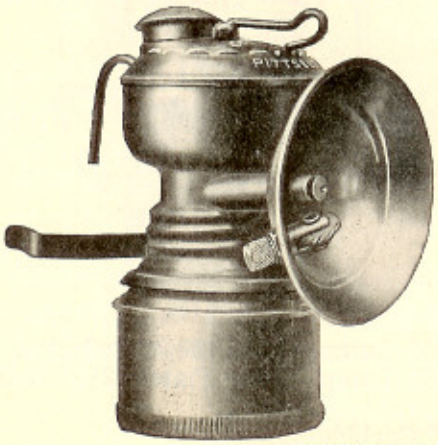
With Detachable Reflector
Flat Hook

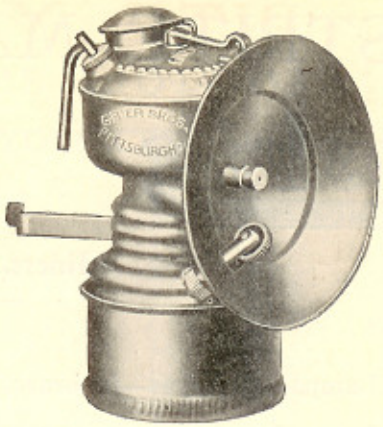
Polished Brass

No. 100C—3 in. Reflector
No. 101C—2½ in. Reflector
No. 102C—2¼ in. Reflector

Polished Nickel

No. 200C—3 in. Reflector
No. 201C—2½ in. Reflector
No. 202C—2¼ in. Reflector





With Soldered on Reflector

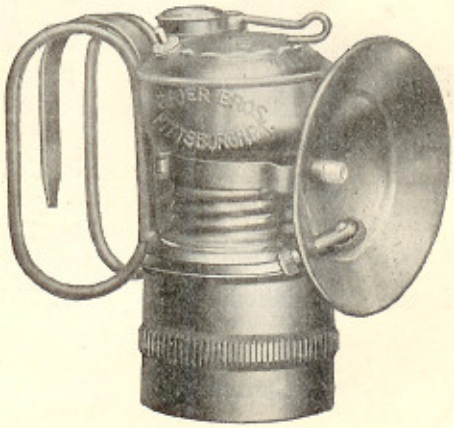
Round Hook

Polished Brass

No. 96 C. S.—2¼ in. Reflector
No. 87 C. S.—2½ in. Refllector
No. 98 C. S.—3 in. Reflector

Polished Nickel

No. 106 C. S.—2¼ in. Reflector
No. 117 C. S.—2½ in. Reflector
No. 119 C. S.—3 in. Reflector



Polished Nickel

Large Carbide Bottom

No. 300C—3 in. Reflector

The ideal lamp for Inspectors, Superintendents, Mine Foremen, Campers, Hunters and for all outside work.

GRIER LAMPS without J. & T. Cleaners are of the same general construction and have the same guarantee as our J. & T. Lamps. Reflectors are soldered and braced to body of lamp.

Polished Brass

No. 96—2¼ in. Reflector
No. 87—2½ in. Reflector
No. 98—3 in. Reflector

Polished Nickel

No. 106—2¼ in. Reflector
No. 117—2½ in. Reflector
No. 119—3 in. Reflector

WRITE FOR PRICES AND CATALOG

JUSTRITE MANUFACTURING CO.

CHICAGO, ILL.

Manufacturers of

Justrite Carbide Mine Lamps

for

Miners, Superintendents, Engineers, Drivers, Pit-Bosses, Etc.

Products

Miner's Lamps—all types—in brass, steel and aluminum.

Miner's Caps—Carbide Flasks—Burner Tips—and all necessary supply parts.

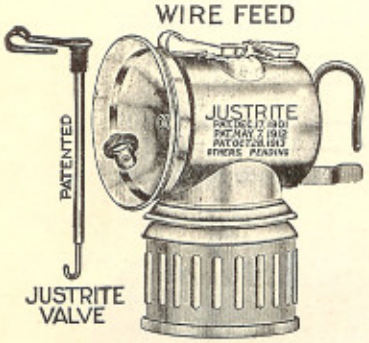
Underwriters Approved Safety and Oily Waste Cans.

The models illustrated on this page are the most desirable for coal miners, and are known as "Coal Mine Lamps."

All lamps are equipped with self-lighter attachment. "Justrite" Lamps are constructed on scientific principles—only the very best material and workmanship being used. Every lamp is guaranteed.

If interested in other models, consult our general catalog.

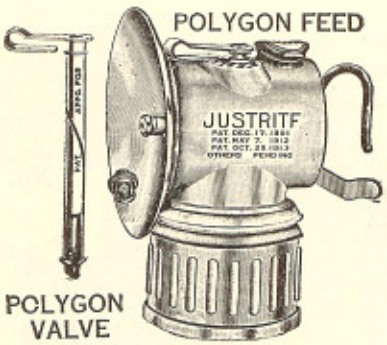
WIRE FEED



2¼" Concaved Reflector.
No. 407 Lamp...Polished Brass

3" Saucer Shape Reflector.
No. 467 Lamp...Polished Brass

POLYGON FEED



2¼" Concaved Reflector.
No. 707 Lamp...Polished Brass

2⅝" Concaved Reflector.
No. 727 Lamp...Polished Brass

3" Saucer Shape Reflector.
No. 767 Lamp...Polished Brass

Specifications

Material	Brass
Finish	Brass or Nickel Plated
Reflectors	2¼" to 3"
Burning Capacity	2½ Hours
Weight	5 ounces
Charge	2 Ounces Carbide
Height	3¾"
Diameter Bottom	2"
Candle Power	16.7

Packed

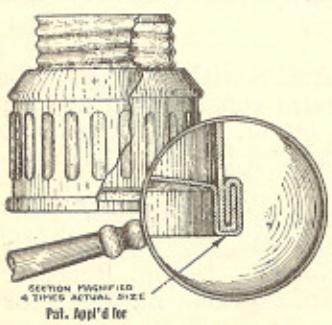
1 Doz. in Carton	6 Lbs.
6 Doz. in Container	33 Lbs.

The New Sparker Attachment

Used only on Lamps Nos. 927-929-967-969.
Write for complete catalog No. 4.

The Strongest Lamp Bottom Made

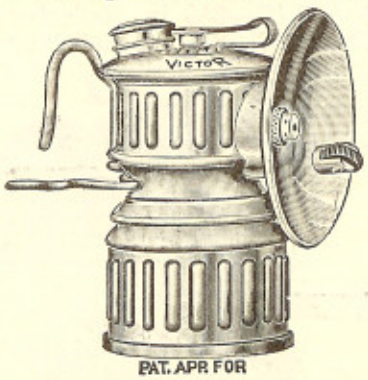
All Justrite Lamps are equipped with this bottom.



No. 965.....Bottom Brass
No. 935.....Bottom Nickel

"Victor" Carbide Lamp

Miners preferring a "Vertical Shape" miner's lamp with detachable reflector will find that the Victor Lamp will give them the best results. The Victor Lamp is very rigid and strongly constructed, all weak points reinforced and strengthened.



No. 661 Lamp, Brass, 2⅝" Reflector.
No. 663 Lamp, Nickel Plated, 2⅝" Reflector.

World's Largest Manufacturers of Carbide Lamps

National Carbide Sales Corporation

342 MADISON AVE., NEW YORK CITY

Factory: Ivanhoe, Va.

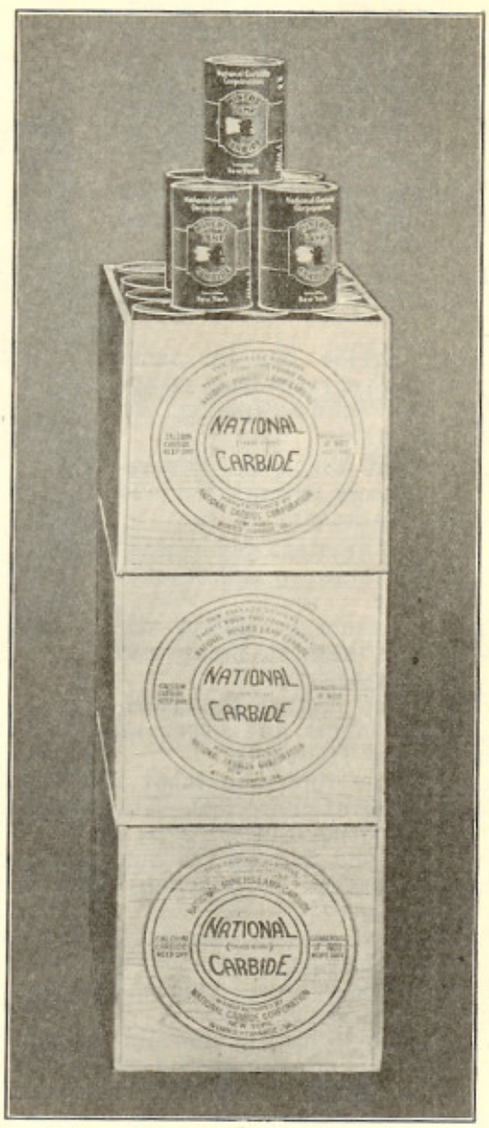
Distributors of

NATIONAL (TRADE MARK) CARBIDE

For Miners' Lamps

NATIONAL CARBIDE FOR MINERS' LAMPS

Is the carbide which gives the maximum amount of light per pound.



This is the Result of—

The use of the purest raw materials obtainable anywhere, as the National Carbide Plant is located within a mile of deposits of the highest grade limestone, and near the coal fields of West Virginia, Virginia and Southeastern Kentucky, from which is obtained the best coke made in the United States.

Proper fusing of the raw materials which is assured by expert engineering and chemical supervision.

Production in the most modern Carbide Plant in the United States.

Careful sizing which assures thorough slacking of the Carbide and easy filling of lamps.

NATIONAL CARBIDE FOR MINERS' LAMPS

Is packed in containers of the following sizes:

100 pound drums
25 pound drums
10 pound cans— 6 cans to the case
2 pound cans—24 cans to the case

NATIONAL CARBIDE IS PACKED IN RED DRUMS

Ask for the Red Drum.

UNION CARBIDE SALES COMPANY

NEW YORK
Carbide and Carbon Bldg.
30 East 42nd St.

CHICAGO
Peoples Gas Bldg.

SAN FRANCISCO
Balfour Bldg.

WAREHOUSES IN 150 CITIES

"Miners Lamp" Union Carbide

Union Carbide For Mine Lamps

"MINERS' LAMP" UNION CARBIDE—Packed in 100-pound drums; 25-pound drums; 2-pound cans—24 cans to the case; 10-pound cans—6 cans to the case.

Manufactured by Union Carbide Company, the Original Producers of Commercial Calcium Carbide and today the world's largest makers of this product.

"MINERS' LAMP" is a size of UNION CARBIDE specially adapted for use in Miners' Carbide Lamps.

Because of its special selection, uniform high gas yield, special sizing and screening, and freedom from dust, "Miners' Lamp" Union Carbide is the most economical and satisfactory Carbide for use in Miners' Lamps.

"Miners' Lamp" Union Carbide will keep indefinitely if protected from air and moisture.

UNION CARBIDE—WORLD'S BEST QUALITY—HIGHEST GAS YIELD.

Union Carbide has for more than twenty-five years been recognized as the World's Standard for Quality in Carbide.

The use of Union Carbide results in greatest satisfaction and lowest cost, because:

It has the greatest gas content and is always uniform and dependable in quality.

Union Carbide is always the same—always highest grade and most carefully selected.

When using highest gas yielding Carbide, lamps and other apparatus require recharging less frequently.

Considerable time and labor is saved by the smaller number of chargings. The time saved can be applied to other duties.

The wear and tear on the lamps, or other apparatus, is lessened by reducing the number of rechargings.

There is a smaller quantity of residue to handle per unit of gas consumed, when highest gas yielding Carbide is used—another worth-while saving in time and labor.

When Carbide having the highest gas value is used, a saving is effected in the cost of transportation and handling charges in proportion to the amount of gas actually generated.

The correct uniform sizing and careful screening of UNION CARBIDE assists greatly in the economical, efficient and uninterrupted operation of lamps and generators.

Because of the faithfully sustained, always dependable quality of Union Carbide, it is easy for the Carbide user to estimate his Carbide requirements from time to time.

What Union Carbide Is Used For

In addition to being used by more than a million miners in cap lamps, hand lamps and other portable and stationary mine lighting equipment, Union Carbide, crushed to the several regular commercial sizes, is extensively used for the following purposes: The lighting of country buildings of all types and sizes; cooking; the oxy-acetylene process for welding and cutting all metals; contractors' torches and flare lights; lighthouses and buoys; train, locomotive, railroad signal and station lighting; motor vehicle lighting; life saving equipment; fire departments; physicians' lamps; scientific and laboratory purposes; searchlights; moving pictures; stereopticans; hunting and trapping, fishing, camping and boat lighting; gathering cotton and small fruits at night; night operation of tractors and other farm implements; steam boiler and other inspection work; and scores of other uses.

Our Blue and Gray Package

Union Carbide is always packed in distinctive Blue and Gray containers. The excellence of our package is in keeping with our aim to diligently protect the interests of users of our product in the matter of Carbide quality from the time it is packed at the Works until it is consumed by the user.

Union Carbide will keep for years in the original package without deterioration.

The Blue and Gray package is, therefore, a symbol denoting: best grade Carbide; highest gas value; uniform dependable quality, and purest gas.

Our Nation-wide Distributing System

For the convenience and economy of Carbide users we carry large stocks of Union Carbide in our own warehouses, at 150 convenient shipping points throughout the country.

Shipments are made the same day that orders are received.

Directory of Union Carbide Sales Company's Warehouses Appears on Opposite Page

Union Carbide Sales Company's Remarkable Service and Distributing System

Shipments are made same day orders are received at our Warehouses located in the following cities. Orders can be addressed to Union Carbide Sales Company, at any one of the addresses given below.

ALABAMA
Birmingham.....12 So. 20th St.
Mobile.....16 So. Commerce St.
Montgomery.....15 Washington Ave.

ARIZONA
Phoenix.....42 So. Central Ave.

ARKANSAS
Ft. Smith.....123 So. 9th St.
Little Rock.....1400 E. 6th St.

CALIFORNIA
Fresno.....932 H. St.
Los Angeles.....639 Gibbon St.
Oakland.....(See San Francisco)
Sacramento.....217 O. St.
San Diego.....7th & J. Sts.
San Francisco, California & Sansome St.

COLORADO
Denver.....19th & Wazee St.

CONNECTICUT
Hartford.....412 Trumbull St.

DISTRICT OF COLUMBIA
Washington .....
.....Maryland Ave. & 9th St., S. W.

FLORIDA
Jacksonville, 13 Cedar St., P. O. Box 124
Tampa.....1702 Grand Central Ave.

GEORGIA
Atlanta.....Haynes & Rhodes Sts.
Savannah, Ogeechee Canal and Broughton St., P. O. Box 78.

ILLINOIS
Chicago.....122 So. Michigan Boulevard
Danville.....511 Oak St.
Decatur.....133 W. William St.
E. St. Louis.....700 Broadway
Marion...315 Granite St., P. O. Box 747
Monmouth.....61½ Public Sq.
Peoria.....100-110 Edmund St.
Quincy.....313 Delaware St.
Springfield.....1801 Washington St.
Streator.....501 E. Hickory St.

INDIANA
Evansville.....1601 Illinois St.
Ft. Wayne.....2206 Broadway
Indianapolis.....601-637 Kentucky Ave.
Terre Haute.....714 N. Fifth St.

IOWA
Davenport.....118 Harrison St.
Des Moines.....3rd & Elm Sts.
Dubuque.....8th & Washington Sts.
Ft. Dodge.....Central Ave. & 16th St.
Ottumwa...207-9-11 So. Washington St.
Sioux City, 925 Fourth St., P. O. Box 398
Waterloo.....1209 E. 4th St.

KANSAS
Pittsburgh.....824 N. Broadway
Salina.....154 No. 5th St.
Wichita....Douglas and Sycamore Aves. P. O. Box 951

KENTUCKY
Allen ..... Beaver Creek
Central City.....306 Broad St.
Louisville.....126 E. Main St.
Middlesboro.....1701 Cumberland Ave.

LOUISIANA
New Orleans.....4124 Toulouse St.
Shreveport.....615 Market St.

MAINE
Portland.....11 Exchange St.

MARYLAND
Baltimore.....19 E. Lombard St.
Cumberland.....18 N. George St. P. O. Box 172
Salisbury.....406 Main St.

MASSACHUSETTS
Indian Orchard .....
Worcester.....15 Federal St.

MICHIGAN
Detroit.....5785 Hamilton Ave.
Grand Rapids..500 Shawmut Ave., N. W.
Hancock.....First Natl. Bank Bldg.
Iron Mountain.....513 Stephenson Ave.
Ironwood .....
Jackson.....518 So. Water St.
Muskegon.....301 W. Western Ave.
Saginaw.....1830-40 No. Michigan Ave.
Saulte Ste Marie.....

MINNESOTA
Minneapolis.....334 N. 1st St.
Virginia.....413 Chestnut St.

MISSISSIPPI
Vicksburg.....1701-3 Levee St.

MISSOURI
Kansas City.....1422 St. Louis Ave.
St. Joseph.....920 So. 6th St.
St. Louis.....(See E. St. Louis, Ill.)

NEBRASKA
Omaha.....1007-9-11 Jones St.

NEW JERSEY
Camden.....Front & Division Sts.
Newark.....251 Ridgewood Ave.

The 25 Pound Drum with Large Screw Top is an Economical, Convenient and Very Popular Package

NEW YORK
Albany.....108 3rd Ave.
Binghamton.....83 Prospect Ave.
Brooklyn.....382 Metropolitan Ave.
Buffalo.....1336 Genesee St.
Geneva.....Exchange St. & R. R. Place
Hurleyville .....
Jamaica.....11 New York Ave.
Kingston.....O'Neil St. near Broadway
Niagara Falls .....
Poughkeepsie .....
Smith St. & N. Y., N. H. & H. Tracks
Utica.....135 Hotel St.
Watertown.....438 Court St.
Whitehall.....22-23 Main St.

NO. CAROLINA
Charlotte....Palmer St. & P. & N. R. R. P. O. Box 777
Raleigh .....
..204 W. Hargett St., P. O. Box 149
Wilmington .....
..Surry St., Bet. Castle & Queen Sts.
Wilson.....700 South Goldsboro St.

NO. DAKOTA
Fargo.....5th St. & 2nd Ave., N.

OHIO
Athens.....Factory and Moore Sts.
Canton.....618 Mulberry Road S. E.
Cincinnati.....67 Plum St.
Cleveland.....631 Hanna Bldg. Annex
Columbus.....330 Dublin Ave.
Dayton.....104-114 S. Wayne Ave.
Lima.....338 E. High St.
Mansfield.....40 W. 3rd St.
Steubenville.....324-343 No. 7th St.
Toledo.....414 S. Erie St.
Youngstown.....Jones & Brittain Sts.
Zanesville.....Main & 2nd Sts.

OKLAHOMA
McAlester.....8 No. Main St.
Oklahoma City.....4 W. Park Place
Tulsa.....1-11 Boulder St., North

OREGON
Portland.....15th & Hoyt Sts.

PENNSYLVANIA
Beaver.....262 East End Ave.
DuBois.....Weber Ave. & Franklin St.
E. Queensburg.....Clark & George St.
Erie.....1426 Chestnut St.
Harrisburg.....25 S. 10th St.
Johnstown .....
.....Messenger St. & B. & O. R. R.
Philadelphia.....2nd & Fishers Ave.
Pittsburgh .....
...1202 Chamber of Commerce Bldg.
Pottsville...Railroad and Sanderson Sts.
Scranton.....Penn Ave. & Vine St.
Shamokin.....5th & Walnut Sts.
Williamsport.....Canal & Court Sts.
Wilkes-Barre....150 E. Northampton St.

SO. CAROLINA
Charleston.....3 Liberty St.

TENNESSEE
Chattanooga.....312 Pound Bldg.
Knoxville.....426 W. Depot Ave.
Memphis.....671 So. Main St.
Nashville.....105-7-9 Broadway

TEXAS
Dallas.....1008 Canton St.
El Paso.....First and Kansas Sts.
Houston .....
..Baker & Cedar Sts., P. O. Box 1214
San Antonio.....115 So. Medina St.
Waco.....13th & Mary Sts.

UTAH
Salt Lake City..108 W. Second South St.

VIRGINIA
Lynchburg.....1324 Commerce St.
Norfolk.....P. O. Box 556
Richmond.....1709 E. Cary St.

WEST VIRGINIA
Bluefield.....195 Roanoke St.
Charleston...Broad St. & K. & M. R. R.
Elkins.....Railroad Ave. & 1st St.
Fairmont.....Auburn St.
Mount Hope.....P. O. Box 536
Huntington.....7th Ave. & 8th St.
Morgantown.....178 Clay St.
Mullens.....P. O. Box 55
Wheeling.....43rd & McColloch Sts.
Williamson.....P. O. Drawer L.

WASHINGTON
Seattle.....304 Railroad Ave. So.
Spokane.....162 So. Post St.

WISCONSIN
La Crosse.....Front & King Sts.
Madison.....513-19 Williamson St.
Milwaukee.....120 Jefferson St.

UNION CARBIDE IS EASILY OBTAINABLE EVERYWHERE

Requests for Information and Special Correspondence Should be Addressed to our New York, Chicago or San Francisco Offices