English version

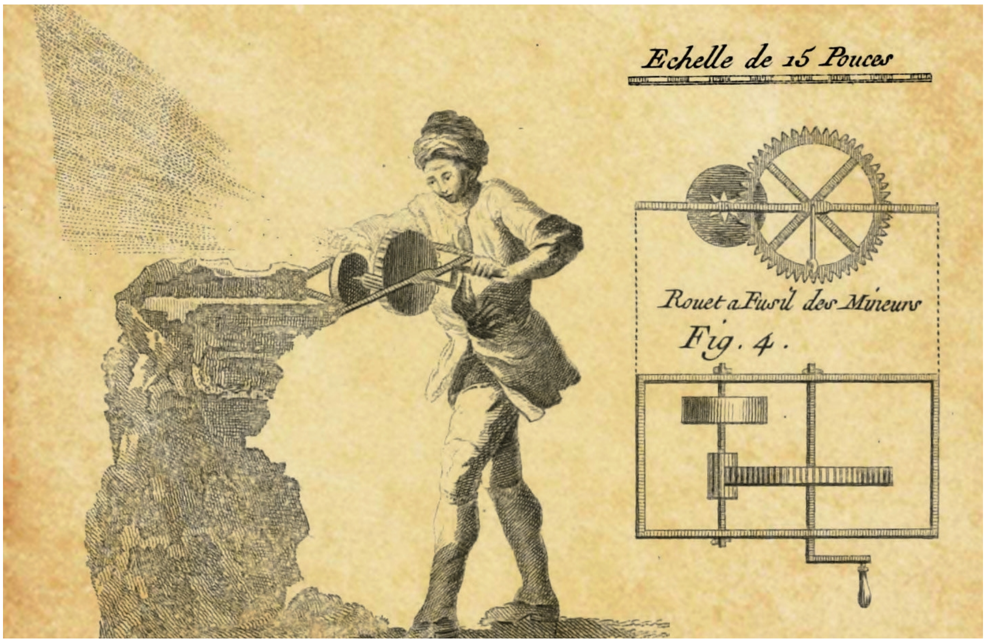
MUSEE ULTIMHEAT®

Jacques Jumeau

History of technologies linked to heating.

Chapter 2

From Miners lamps to explosion proof equipment. Short history.



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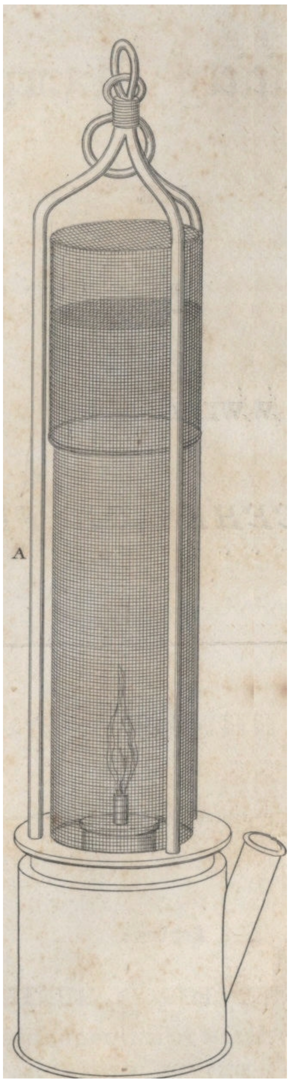
The explosion of firedamp in mines caused by the flames of oil lamps, was the cause of many accidents and caused hundreds of deaths. This explosion had a double danger: methane gas and coal dust. When the methane exploded, the explosion was generally followed by a much more violent explosion of dust (the dust explosion) produced by inflammation of the cloud of coal dust produced by the initial explosion.
The oldest listed, but certainly not the first tragedy, was the one of the pit of the Barbeau de Wez, near Liège in Belgium, which caused 94 victims in 1514.

The first device that seems to have been developed to limit explosions, the Flint Mill (also named Steel Mill), was invented by Carlyle Spedding around 1730, and was used in England at that time. It was the result of empirical observations of the time that the sparks of a tinder lighter or that the simple incandescence of a red-hot iron was not enough to ignite the firedamp. Indeed, as it will be demonstrated later, firedamp ignites only from a durable heat source and at a temperature greater than 650°C, which is achieved only by a flame. (This concept of ignition temperature is included in current explosion-proof standards under the concept of surface temperature, and this notion of minimum ignition energy is the point developed by intrinsically safe explosion-proof devices).



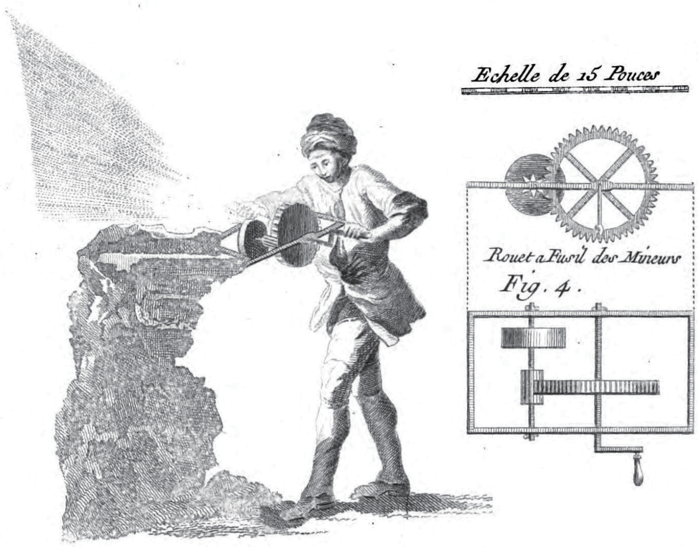
1815 the miner safety lamp, invented by Humphry Davy

This device is first quoted by Jars in his " Voyage métallurgique ", (year 1765, twelfth memoir, P245), and it is described a second time in 1770, in more detail, and with a sketch, in the book on exploitation of the coal mines of Jean-François-Clément Morand, of which follow a long quotation:
"... In the coal mines are between Mons, Namur, Charleroi [In Belgium] and elsewhere, they call it “Terou”, “Feu brisou”. In Liege they call it “Feu grilleux”, “Feu grieux”… The coal miners know that they are threatened, and that it will light, by the very natural effect that it repels the air from where it comes; also, as soon as they realize it, they extinguish their candles.
They knew they were just going to do without their lights, they were in the form of blue sparks, so they were going away throwing something or dry dust on a flame.
They even know how to foresee it fairly well, when around their candles blue-sky sparks are formed, as it is done by throwing some salt or some dry dust on a flame.
In coal mines where the air circulates freely, one does not worry about it, and it serves as entertainment to the workers; informed that the mine is well ventilated, they watch for these vapors, which they hear sparkling and see them emerging in the form of white threads; they seize them before they reach their candles, crush them in their hands.
.... In other collieries which are very sulphurous, and where this accident is very frequent, the worker, only enlightened by experience, enters the mine and works in it in the deepest obscurity. Experience has shown them the danger of working with lights ...
In the coal quarries of Newcastle, these "Pit-Mens", or workers in this part of England, distinguish two species of vapors, the one they call "Stith", perhaps by the corruption of the word Stink, Stench, is nothing else than the "common Damp", called in other mines of England "foul air".
The second is a sulphurous vapor, different from the first by its flammability and its other phenomena: indeed, far from concentrating the flame of the candles or extinguishing it, it increases it and extends it to a marked height; the candle flame then makes the effect of a wick which lights all the part of the mine where there is this vapor at this moment. At Pensneth-Chasen, fire was set in this way by a candle, in a coal quarry, and from that

time one can see smoke and sometimes flame; in Flintshire, at Mostyn, there is from time to time in the mine, exhalations of blue color, igniting with explosion.
One circumstance by which this sulphurous and inflammable vapor, "Fulminating Damp", is remarkable, it is in some mines that it curls up and collects itself at the top of the galleries, in the shape of a balloon which one can perceived with eye.
In the Wittehaven mine, once they saw one of eight feet in diameter; it is still singular, if we are to believe those who frequent the Newcastle Mines, that, although this vapor is lit by the flame of candles, the workmen when working by this vapor, usefully use with impunity their lighter and their flint, to draw a brilliant light, for the benefit of which they light up without incurring the same danger as with lamps and candles.

This simple remark, first made on occasional sparks shot at different times from a flintlock, led the Pit-men to imagine a way to take advantage of the fire they had since devised. unable to produce on this vapor the dreaded effect of the fire of the lights with which they illuminate; they are so convinced of it that they obtain at will, and for a certain time, clarity by turning a little steel wheel on a flintlock.
The whole machine is called "Flint mill"; it looks very much the spinning wheels of our harquebuses and could truly be called the Miners' Rifle Wheel.
It is easy to imagine the considerable and successive sheaves of light that the flint stone gives against a piece of steel; there is certainly a difference between this fire, always accompanied by a very considerable fresh wind, and that of a light; nevertheless, the touchwood is fired up with the sparks produced in the open air and in a cellar by the wheel of a knife grinder rubbed by the instruments it passes over: although the good spirit of wine does not catch fire, this curious means to dissipate a disturbing obscurity in the mine for the works, is not so certain, that one can rely on it with full security: M. Jars himself quotes in his Memoir the example of an inflammation which resulted from the sparks of Flint mill. All that can be said is that, in the case where the ordinary exhalation, "Common damp", otherwise called "bad fog", and "fouma" by the mine workers of Liège in Belgium, exists to a certain degree, that is to say, that in places where there is a lack of air, the rifle-wheel does not give any light, and must be considered one of the least dangerous means.
This Flint Mill was presented to the Royal Society in 1734 by Sir James Lowter as offering all the security guarantees. He was the cause of several explosions in the area of Newcastle on Tyne, which one apparently caused the death of its inventor in 1765.

Flint-Mill Rouet à fusil des mineurs



Profile of the rifle wheel, which the workers of the Newcastle mines in England use to light themselves with less risk in underground mines exposed to detonating steam which easily ignites the lights. This wheel has four feet, instead of being simply supported (as seen above) in the hands of the worker.

Jean-François-Clément Morant adds about the firedamp "In England and Scotland, the workers have imagined a very special way of getting rid of it; it consists in not waiting for the fire to reach the point of explosion, which would often be unforeseen and unfortunate for them: they decide this effect by warning themselves, as we judge it well, during their operation, of which here is the process. A man covered with damp cloth or oilcloth goes down into the mine holding in his hand a long pole, the end of which carries a light which is fastened in a slot; he approaches the place from which the vapor comes, advancing its light; and as the shock of the explosion is always blowing on the roof of the mine, which is the upper part of the galleries, it is held tightly on the floor to protect itself from the shock; the vapor catches fire instantly, detonates with a noise similar to that of thunder or artillery, and escapes by one of the wells. The worker who proceeds with this work, first recognizes whether these vapors are present in too great quantity, because, in this case, the light of the workman is extinguished; then he leans more against the ground, warns his comrades, shouting them to do the same; the flaming vapor does not hit those who have been the quickest to comply with the advice, and those who have not had time, are killed or burned.

Nearly 60 years later, in France, this exact method was always used and was described in 1848, by Alphonse Meugy in his book " Historique des Mines de Rive-de-Gier"

It consisted of hiring miners, volunteers and better paid, to ignite the gas every day. The firedamp was "lit" before the arrival of the miners the worker was called penitent (because of the suit he was wearing) or gunner.

It was also used ponies with a burning candle. The ponies were watered and sent to the galleries in hopes of creating very small explosions.

However, as early as 1783, in Belgium, the "Société d'Emulation de Liège" had been the initiator of several inventions to solve the problem of the lighting of gassy mines, which remained unimplemented.

Following the repetition of the accidents in the English mines, the English engineer Humphry Davy was charged with finding a technical solution to the problem of the lighting of the mines. On November 9, 1815, Davy, having noticed that a flame enclosed in a very fine mesh does not ignite the firedamp, presented the result of his researches to the Royal Society on a memoir named « On the fire-damp of coal mines, and on methods of lighting the mines so as to prevent its explosions ». The Davy lamp had 210 meshes per cm^2, but similar patterns made later by Stephenson, Dubrule and Clanny had wider mesh screens, with only 132 meshes per cm^2. Davy himself modified his lamps up to 121 meshes per cm^2. This notion of minimum gap is taken up in the current standards for the definition of explosion-proof devices type "D".

Davy's lamp was used as early as 1816 in the Newcastle Basin in England. In 1825 the Davy safety lamp was made mandatory in France by an order of the Minister of Public Works and Mines. The practice of the "penitent" or "gunner" was proscribed in the mines around 1835.

This lamp, which was called "the Davyne" in France, seemed likely to provide all the necessary safety guarantees against ignition of firedamp but after many explosions occurred in coal mines where this lamp was used, it was soon demonstrated it was not flawless, and that it could only reduce the chances of explosions, without preventing them in all cases. In particular, it had the following defects:

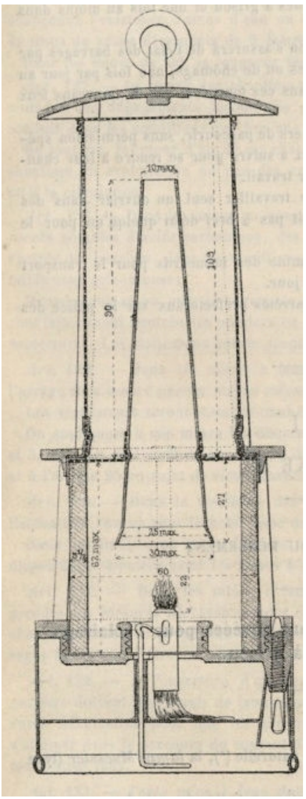
- The inflammation of a mixture of air and carbon hydrogen can occur through the metallic canvas, in galleries where there is a quick airflow, because then, the lamp flame blushes the mesh or passes through.
- The slightest shock can deform or even tear open the mesh, and thus render the lamp ineffective.
- The metal-mesh in contact with the oil reservoir, is soon greased and traps fuel dust, thus forming a paste which can be ignited, both inside and outside.

As early as 1816, at the request of the Mons Chamber of Commerce, Davy's lamp was tested in one of the most gassy mines in Belgium, that of Tapatout No. 2. Here is an excerpt from the test report of the time: "In the colliery of Tapatous-sur-Elouges, with the aid of the safety lamp, a dangerous work was done which was formerly done in the darkness, and was therefore very long. The “Grisou”, for it is thus that the workers call the hydrogen gas of the mines, the firedamp ignited in the metallic network of the lamp up to fifty and a hundred times a day of the worker, without communication of the inflammation to the outside

It was a big progress; Quickly various inventors tried to remedy its imperfections. In particular, in the report of the fair of Ghent (Belgium) in 1820, the jury notes: "We know that the lamp of miners, which bears the name of its author the famous chemist Davy is built on the principle that the detonation of carbon-containing hydrogen gas does not penetrate a metallic fabric of a certain fineness. M. Dechevremont, of Liège, by improving Davy's lamp in a number of ways, has, among other things, made a very remarkable improvement in the application of a copper cylinder, pierced with various small holes, at the place where the aqueous vapor, produced by the combustion of the gas, promptly oxidized the upper and very soft part of the wire cloth. The commission judged that the improvements made to Davy's lamp by M. Dechevremont, of Liège, deserve a great deal of attention and gratitude. She recommends her work for the protection of Your Excellency, and proposes for her a silver medal, while she makes a very honorable mention of it. She thinks worthy of an honorable mention M. Descamps Mansuede, of Dour, who has exhibited two Davy lamps, well made, and M. Cambresy, of Liège, exhibiting a lamp with two concave mirrors”.

In 1842 the Liège engineer Mathieu-Louis Mueseler invented a lamp that had the following advantages:

- It is quickly extinguished when there is plenty of explosive gases, even in a mixture with pure hydrogen.
- It shines best and can be placed away from the worker and free tools, and best suited in galleries having strong air streams.
- The wire mesh, being remote from the tank , do not permeate to oil. Only a dry dust can stick but it is easily removable.
- It is provided with two wire meshes, one horizontal and the other vertical, so that one remains intact when the second is to be torn.
- Finally , the air flow to activate the combustion is from top to bottom instead of being laterally, provision that gives the inestimable advantage over all other safety lamps, of turning off suddenly when the air is charged with sufficient carbon hydrogen to provide an explosive mixture.

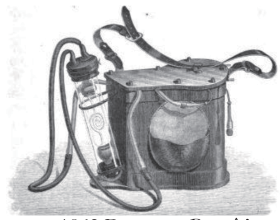

1842 The Mueseler miner lamp

This lamp spread in the basin of Seraing and other coal centers in Belgium and, in 1864, its use was prescribed by the Belgian Government. It was then adopted in a number of mines in France and England.

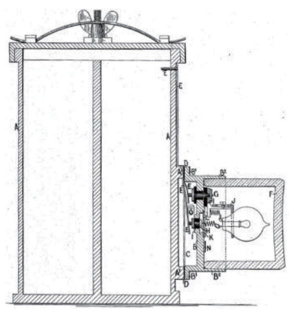
Lighting miners became safer. The use of these lamps, however remained linked to the respect of safety, and there were many accidents resulting from human carelessness. Here is an example, one of my ancestors, Auguste-Joseph Jumeau , was one of the victims :

On Saturday, March 6, 1852 , at the pit " Ferrand " at Elouges in The Borinage (Belgium), the morning shift just came down in the galleries, it was the last day of work in this mine, as it should be closed to allow upgrades and safety works. The pit had a small diameter and allowed a two buckets traffic only (large casks used to bring the coal up to the surface and the movements of people) attached to hemp ropes.

At 20 meters of the hanging point, at the entrance of a gallery, was a tank containing water for the mine horses. Around 10 AM, the worker in charge of treating horses went there to draw water. As the lamp did not light enough (probably a Davy lamp type), he imprudently opened it. As soon as the flame in contact with the atmosphere, an explosion rocked the mine. The horse trainer was thrown against a wall and was horribly burned. He survived nevertheless. His many companions were less fortunate: 63 miners, men, women and children were killed.


1862 Dumas et Benoit's Electrical miner lamp

A risk still remained to be solved: the ignition of the lamp, which forced to back it out of the well if accidentally extinguished. In the 1890's, when kerosene replaced oil in lamps, electric ignition systems for miner lamps were tested, having enclosures that did not let the flame out (Patent by William Ackroyd, Morley, England).
The first electric portable lamps with batteries offered at the Academy of Sciences of Paris en1862 by MM. Dumas and Benoit, did not definitely meet safety requirements, unlike earlier expectations that set forth their lighting tube enclosed in a sealed tube as not fearing the ignition of firedamp (featured in the Journal of Industrial Engineering, July 1863).


1884 Cad electrical lamp

In 1884, English Theophilus Cad, from Forest Gate, England, invented an electric lamp whose switch was enclosed in what can be considered the first electrical flameproof enclosure (British Patent No. 806 of 5 January 1884).
Timidly used from 1890, electric lamps grew very slowly between 1920 and 1930.

But shortly after the introduction of electricity in coal mines, it was also discovered that lethal explosions could be initiated by fixed electrical equipment such as lighting, signals or motors.
Around 1910, 12 volts DC signaling systems considered safe appeared.
However, in October 1913, took place the largest explosion of British mines, that of Senghenydd Colliery, where 439 miners perished. It was suspected an alarm system, consisting of two parallel bare wires running along the galleries, which allowed any miner wishing to report a problem to the surface to make it by contacting momentarily the two wires with a metal tool. But the bell inductance coils caused a spark, which was probably the cause of the explosion. It was then determined that these products might be secured by a careful design, the forerunner of the "intrinsic safety". Following this disaster, the miners demanded the withdrawal of the electrical equipment of pits. Then began the development of electric devices called "explosion proof", which inevitable sparks could only occur in a protective envelope preventing from igniting the surrounding gas.
Historically, the topic of Hazardous (Classified) Locations first appeared in the National Electrical Code (NEC) in 1923, when a new article entitled "Extra-Hazardous Locations" was accepted. This article addressed rooms or compartments in which highly flammable gases, liquids, mixtures or other substances were manufactured, used, or stored. In 1931, "Classifications" consisting of Class I, Class II, etc., for the hazardous locations were defined
In the investigations leading to approval of loading and conveying machines the bureau is guided by the provisions of Schedule 2C. issued on February 3, 1930. This schedule classified the various electrical parts according to their liability to sparking and specified the type of enclosure to be used for each class. As required by the schedule, a part that may produce sparks during normal operation must be enclosed in an explosion-proof casing; that is, an explosion of gas in such a casing must not ignite the gas surrounding the casing or discharge flames from any joints, bearings, or lead entrances. The object of the bureau's investigations is therefore to determine by test and inspection whether or not the enclosures are suitable to the

purpose for which designed. The explosion-proof qualities are demonstrated by tests in which gas is exploded within the casings. Other tests are made to check the adequacy of electrical clearances and insulation. In addition to the tests, a detailed inspection of parts, including a careful check against drawings and specification is made. These drawings constitute the chief record of the equipment investigated and therefore must be complete in detail to cover adequately the construction to be approved. A description of test equipment and methods followed in conducting these investigations is given in Bureau of Mines Bulletin 305, Inspection and Testing of Mine-Type Electrical Equipment for Permissibility, published in 1929.
In Europe, the first German standards on "The protection of electrical installations in hazardous areas " were published in 1935, and gave guidelines for the installation of electrical equipment in hazardous areas. In 1938 appeared a fundamental change dividing the installation requirements (VDE 0165) and the design requirements of products (VDE 0170 / 0171).
Standards of product design included the types of basic protection against explosions such as flameproof enclosures, immersion in oil and increased safety. Components were designed to be protected against explosions and housed in industrial type housings that were resistant to weathering. This led to the development of flameproof components mounted inside increased safety housings. Devices designed to this standard were marked with the symbol (Ex). During the 1960's, the European Community was founded to establish a free trade area in Europe. To reach this goal, technical standards needed to be harmonized. Consequently, the European Organisation for Electrotechnical standardization (CENELEC) was created. A new set of European standards describing devices for explosive environments (EN 50014 - EN 50020) was published in 1972. In 1975, the first EU directive for devices used in hazardous areas, known as "Directive on the protection against explosions ", was published. In 1978, the first edition of European standards was published by CENELEC which covered installation techniques.
IEC standards currently in force in 2014 for equipment for explosive atmospheres are:
IEC 60079-1: Flameproof enclosures "d",
- IEC 60079-2: Envelopes internal pressure "p",
- IEC 60079-5: Powder filling "q",
- IEC 60079-6: oil immersion "o",
- IEC 60079-7: increased safety "e",
- IEC 60079-11: intrinsic Safety "i",
- IEC 60079-15: Type of protection "n",
- IEC 60079-18. Encapsulation "m".
They are supplemented by the following equipment standards:
- IEC 60079-25,
- IEC 60079-26,
- IEC 62013-1,
- IEC 62086-1.
At their transcription into European standards, the IEC prefix is replaced by EN.