VENTILATION OF MINES.

I KUHN.
Ventilation of Mines.

In the working of mines, one of the first and most important considerations is that of ventilation. In order to operate mines, men and animals are necessarily required, which continually require a fresh supply of air to sustain health and life, and hence by ventilation of mines, we mean the manner and methods employed in exhausting from a mine the vitiated air and obnoxious gases, and replacing them by fresh air.

Ventilation with respect to its importance is divided into two classes, 1st that of coal mines and 2nd that of metalliferous mines.

The air in coal mines is not alone contaminated by the men and animals engaged in severe work, the burning of numerous lights by the smoke and dust resulting from the use of explosives and aqueous vapor from various causes, but the very coal that is being mined at least as much of the surface as is exposed to the air is continually absorbing the life sustaining oxygen and giving off suffocating and poisonous gases. The amount of air required for the health and safety of the men will very much in different localities depending upon the condition of the mine, gases, or not, extent of workings, number of men, animals, &c., employed.

We will now consider the gases met with in mines which, when insufficiently diluted with atmospheric air, are productive of deteriorious effects upon the workmen, or capable of forming with it an explosive compound are first.
carbonic acid (CO₂) called by miners black-damp, it is incombustible, in-explosive, and unfit for respiration, its specific gravity as compared with air is 1.52. When mixed with air it of this gas becomes unfit for the support of combustion and lights burn badly in an atmosphere containing 5 to 6% of this gas. On account of its great specific gravity, it tends to occupy the lower parts of excavations, where its presence can be detected by inserting in it a light. Black-damp is in many mines disengaged from the fissures and cavities in the strata, and is found more or less, to result from the respiration of the workmen and horses also from the combustion of lights and deflagration of gunpowder.

2. Fire-damp, or light carbonated hydrogen (CH₄) has a specific gravity of 0.56. If mixed with air in the proportion of 1/30 to 1/5, it becomes highly explosive and if the proportion of fire-damp is increased still further, it burns without explosion and if this proportion exceeds one-third, it causes suffocation. This gas is commonly found to float along the upper portion of levels and may be detected by the "cap" on the flower of a candle inserted in it; when mingled with air in the proportion of 1/30 to 1/5, in fiery seams it may be observed escaping from freshly broken surfaces with a hissing sound and is found in the greatest abundance in the neighborhood of faults.

3. Sulphuretted hydrogen (H₂S), characterized by its odor of rotten eggs and has a very deleterious effect on the animal economy. Generally escutte from a decomposition of iron-pyrite but rarely found
in mines. 4th carbonic oxide (CO) when or stone damp, does not explode in a mixture of air but burns brilliantly and is most deadly poison. However, its occurrence is very rare, specific gravity is 0.97.

The means of ventilation are natural and artificial. The difference between the temperature of a mine and that of the external air combined with difference between the levels of the openings at the surface produce a circulation of air through the mine. Thus we have two shafts of unequal depths to the same level underground, in case the internal temperature is greater than the external, the rarified air will rise and pass off through the shaft of the more elevated opening, AC, while its place will be supplied with pure air passing through the shaft of the less elevated opening DB. But in case the external temperature is less than the internal, as in winter, the direction of the current will be reversed.

The increased temperature of a mine is due to several causes. The rock itself below the line of constant temperature increases more or less variably (1°F for 50 to 60 ft) as we descend, hence the deeper a mine the greater its temperature. Much heat is also produced by respiration, combustion of lamps, chemical decomposition, friction of air and other moving bodies.
Natural ventilation may be found efficient and continue uninterruptedly in the same direction throughout the year in deep mines where the air becomes heated to a high temperature, and serves all purposes of metallic mines having few ramifications but is almost entirely inadequate in collieries. Generally, they are shallow and extend over a great area. Hence we must artificially aid the ventilation.

**Artificial Ventilation.**

The principles involved in artificial ventilation are those of propulsion and exhaustion. The powers employed in propulsion are water falls, bellows, force fans, and sometimes force pumps. Of these, the first is sometimes applied in collieries; the remainder only in metallic mines to conduct the ventilating current to isolated places of difficult access. If water be allowed to fall down the dry ascent shaft of a mine, a circulation of air through the mine may be produced. Unless there is an assistant natural outlet for the water, this would be a very expensive method if the water had to be raised to the surface again.

The principle of exhaustion is more generally applied, and with far greater economy and effect than that of propulsion. It is put in practice by furnaces, steam jets, and machinery.

The power of ventilation most usually adopted consists of a furnace or fire in the vicinity of the ascent shaft; in small mines furnaces are sometimes placed on the surface and surmounted by a chimney. But the
plan only generates a limited pressure and circulation of air, at a
great cost of fuel as compared with the ordinary mode, which consists
placing the furnace underground, so that, the up-cast shaft itself forms
the chimney and creates a very much stronger draught from its
length being generally much greater than the chimney connected
with the furnace at the top of the up-cast shaft. The effect of the
furnace in creating a current of air in miles arises from the
expansion and consequent lessening of the density of the air in
the up-cast by the additional temperature imparted to it over that
prevailing in the air of the down-cast shaft. The equilibrium is
destroyed by the column of air in the up-cast being lighter than
in the down-cast, and the excess of pressure in the down-cast shaft
would force a current of air through the connecting drift or workings
to add over the furnace. The furnaces employed in mines which
do not generate explosive gases, are quite simple in their construction
consisting of a number of elevated fire-bars placed in a brick
arch-way a short distance back from the up-cast shaft. But
to avoid explosions of fire-damp in fire-places and to prevent
any conflagration which might arise from the heat of the furnace
causing ignition of coal, more improved furnaces must be used.
The figure on page 6 shows the cross and longitudinal section of a furnace
now generally used invented by John Smith of England.
a and b are two arched spaces over the fire, through which the air can pass.

c and d two air-gates, a circulation of air, through these cools the walls between the furnace and coal. The furnace drift D is gently inclined to the return shaft to prevent the backflow of the smoke. If the return air should be foul, it is led through the higher passage B and a small current of fresh air is supplied to the furnace directly from the down cast shaft.

The furnace power and consequently the current in mines are affected much by changes of temperature on the surface from winter to summer or any sudden fall of the barometer, and where a regular quantity of air is desirable more controllable means of ventilation must be adopted.

Vigorous attempts have been made of late to substitute for the furnace the mechanical action of steam-jets. The subject has been elaborately tried in practice by some of the first Mining Engineers of England, and it has been shown that high pressure steam generated either at the surface or underground and allowed to escape from a series of small jets—say 30 to 40 in number—might be capable of doing good service as an auxiliary at times of accident; but it utterly unable to compete in economy or efficiency with the furnace.
We will now consider a few of the vast number of mechanical contrivances employed in the ventilation of mines; of these, face fans are the earliest in use and are now more generally employed. Fig. 1, Plate N., shows a front elevation of a face invented by M. Frédéric, of Belgium, which consists of a large wheel with a central opening for the entrance of the air, eight radial shutters which are firmly attached to the arms of the wheel, thus admitting of a high rate of speed from 100 to 200 revolutions per minute. Walls are built on each side of the fan as shown in the figure, also an arch over the fan and a chimney. A sliding shutter is fixed into the each iron grooved rails for about 1/5 of the circumference, enlarging or diminishing the outlet to suit the special requirements of the mine over which the ventilator is placed.

Frédéric’s fan is on account of its simplicity and efficiency, now almost universally used in this country. Fans and blowers have been patented, used either for exhausting or blowing, which are now very extensively employed. Of these, the most prominent are Sturtevant’s fan and Root’s blower. These machines are exceedingly simple in their construction and will run for years without repair of any kind. Root’s exhaust blower is claimed to be especially adapted to the ventilation of mines and it is the only kind that is used on West. It is claimed by mine managers that these machines produce a larger and more potent current of air and are more economical than furneels; their use in fire-rooms
collieries is accompanied without danger and they are the only safe means that can be employed in ventilating mines which have only one shaft.

Air-pumps are sometimes employed in producing ventilation in principle they work the same as our common air-pump of the physical laboratory, only on a much larger scale and worked by water or steam power.

We now consider the distribution of air through the workings of a mine, remembering that without due attention to its details, we may have a storm of ventilating wind in the shafts and yet a deadly stagnation in the interior of the mine or one portion of the mine safe and wholesome, another foul and surging or explosion.

In order to carry the air current up to or near where the men are employed, it is necessary to cut a drift or windway across from one gangway to another and as the work advanced, old openings are closed by doors or stoppings, so as to force the air through the required passages only. The special system employed for the latter distribution of ventilating currents depends upon the nature of the mine, the manner in which the coal is worked out and instead of workings. A single current may thus be carried to the various working places and brought back to the up-cast and if the doors and stoppings are in good order, it will be maintained for a length
of several miles without serious loss; this method will be very effective in some mines, but it would be highly objectionable in complicated workings, especially if fire, it would the mass of the openings inside of the working "borders" dead or stagnant, it would needlessly carry fire-damp from dangerous to otherwise safe places, and it is, in order to counteract the afore mentioned evils, the air is "split" and conveyed by special currents into the respective workings of the mine and the returning currents are conducted into the future air-waves without coursing through the other workings. To do this more effectually, it is necessary that the mine be laid out in "districts" or "panel". Fig. 2, plate 1, shows how the air is conducted through a part of the workings of St. John's coal-mine. In figure and fig. 1, shows the ventilation of one of the English collieries.

In order not to enfeebles the currents too much, the splitting should not be carried too far, and the air-waves should be uniform and free from projecting and obtuse angles, it is also desirable to have large air-waves both before the air reaches the point where it is split and also after the splits of air have been reunited, inclusive of the size of the down-east shaft and where mechanical ventilation is employed of the up-east shaft-also.

It should be evident to everybody that this is the only proper and most economical method of airing a mine, but it is rarely employed.
Plate No. 1.
Showing direction of currents in Coal-mines

Fig. 1.

Goaf

A Brattice Stoping.
A Stone

R = Regulator

Fig. 2
here in our present system of mining, however its use should be urged and made for the purpose if necessary.

We will now pass to the 2nd division of the subject, which will briefly consider.

Very little or no difficulty is experienced in effecting the free ventilating of most metalliferous veins, as they do not extend over a great area, very rarely gaseous, and are in communication with the surface either by adits or connected shafts. However, if the work is prosecuted to a very great depth or confined in minute passages as in the bonanza and copper mines, natural ventilation alone will not suffice.

One of the simplest and most efficient appliances formerly used to conduct fresh air to the laborers in the Gould and New Jersey, or the Cornish, lode, was the water-blast consisting of a wooden box (Fig. 2, plate 2) standing in the shaft, some 200 ft. high and connected at the bottom with an air-pipe A. The top of the box P is open and a finely divided stream of water falls into the box which descends with it a volume of air. The bottom of the pipe P dips into a box B, 2 or 3 ft. long and 15 in. deep, in which the water is allowed to stand above the bottom of the pipe, and from which the excess escapes through a sliding gate or valve V, connected with the water-pipe just above the box B, is the air-pipe A leading to the point to which the fresh air is forced. The air coming down the
standing pipe P, with the water and having no other means of code
is driven along the horizontal air-pipe A, and delivered at the deck
point. This is certainly a very simple and cheap method of ventilation
and might answer the purpose for one level or tunnel but would be
insufficient for an entire mine.
The deeper mines of the country side, on account of the increased heat
have been forced to resort to other means of ventilation than the one
just explained and have adopted the method of forcing the air down
the mine and into the several levels where it is most needed by means
of a Root's blower. This machine has been found very efficient
and has given much satisfaction to the mining companies that employ
it. The one used at the Ohio is driven by a small engine provided
especially for this purpose. The blower is calculated to run
at 300 revolutions per minute, but with one-third this speed it forces
air down 700 ft. in the shaft and thence to the end of the drift several
hundred feet more. The air is conducted down the shaft, and along
the drift in a square wooden box pipe.
This method of forcing fresh air in the mine is almost entirely
entirely discarded by the English mine viewers. It is certainly more
practical to employ the blower in exhausting the foul air
instead of forcing in fresh air and probably before long the country
managers will be compelled to adopt the former method.
In the above brief account, we have attempted to give an outline of the devices employed in ventilation which may seem to be quite numerous but with the prospective increase of the mining industry in this country, new and more effective measures will have to be adopted.

Finis.