M.V.S. July, 1949

PRESIDENTIAL ADDRESS

A REVIEW OF VENTILATION THROUGH THE AGES

By R.E. Campbell-Pitt

Part 1.

The Oxford Dictionary defines ventilation as: "A stir or motion of air; a breeze; the admission of a supply of fresh air". Ventilation can mean the percolation of fresh air through the specially provided openings in our homes; or the mechanical displacement of the air in large public buildings, cinemas and offices. It can mean the renewal of air in factories to remove undesirable products resulting from industrial processes; it can mean the air that slips through the interstices of our clothing as we carry out our daily tasks or our often more strenuous sporting activities. It can mean the air which seeps into every nook and cranny of a hole in the ground or cave or down the shaft of a Mine, enabling the miner to breathe as he hacks his way through rock which no breath of cooling wind has touched since it was laid down as a molten mass or pressed into its present consistency. It is with this last aspect of ventilation that I propose to deal.

Ventilation does not necessarily mean an artificial movement of air. Although, since mining is now carried on at great depth, we are accustomed to think of Mining Ventilation as a movement of air artificially engendered by fans and pushed down a shaft or through workings, it was not always so. When mining first began, ventilation was a natural process; air simply filled up the spaces where men removed other substances from the earth. But man's greed caused him to dig deeper and deeper for precious flints and minerals until he reached a point where he could no longer breathe because of the dust he created and because the heat and poor supply of air was stifling. Man knew that the prizes he sought lay just below his finger-tips, yet he could not reach down to grab them. He realised, however, that if he could supply fresh air to those working places under the ground, he would be able to survive in deeper holes, and dig out more of the precious materials he sought. So he invented ways and means of doing so. Never was a clearer case of necessity being the mother of invention; man's safety depended on his weapons; his weapons were fashioned from mined materials; therefore he invented machines to help him to work underground when the earth, literally, became too hot to hold him. Artificial mining ventilation was born.

Let us go back for a moment, gentlemen, and examine briefly the natural ventilation of the first mines, before the necessity of machines for moving air was made manifest. The earliest evidence of mining reaches far back into prehistoric times. Paleolithic, or Old Stone Age, men were the first miners,(2) obtaining several products such as salt, ochre and flint. Flint was of major importance to Paleolithic tribes for making knives, axes, arrow-heads and other implements.(2) Their very existence depended on these weapons. No wonder, then, that they nosed out the flint even when it lay, not on the surface, weathered and free, but imprisoned in the earth.

/Thousands.

Thousands of years passed between the time that man began deliberately to chip and fashion stone artifacts, and the time that he began to dig deep into the earth in search of raw materials. Ice hardened the ground. His digging implements were only sticks, stones and antlers. Later, marshes, soggy and bubbling with methane, made digging difficult, but man won. On the downs and firmer ground, he found the desirable flint. He prised it from the surrounding chalk. He dug deeper and deeper with his primitive instruments, till, in neolithic times, the mining of flint became an important industry,(3) and, incidentally, the first specialists came into existence.

Neolithic man discovered that he could work the freshly extracted flint before it lost its quarry waters much more easily than the dead flint found on the surface.(2) He developed techniques of chipping and polishing the stone which we cannot copy to-day. His mines have been found all over Europe and in the United States. All follow more or less the same pattern. First, trenches of varying depths were dug. This trenching has been described as the "open-cast" method.(2-1) When the surface outcrops were exhausted, the miners developed the technique of sinking shafts and driving galleries. According to Rosen,(2-1) the neolithic miners began operations by driving a gallery into a hill from the line of outcrop; later they sank shafts from 32 to 39 feet deep, through layers of gravel stones and sandstone to reach the chalk seams in which the flints were buried.(3-2) The shafts were from 2 to 2½ feet wide.(3-3) The bottom of each shaft was hollowed out into a central chamber from which six or seven galleries, just large enough for a man to wriggle through, extended like the spokes of a wheel. The various galleries were connected by a system of doorways, creep-holes and still smaller openings. We dare not assume that the doors were made for ventilation purposes, but it is hard to think of any other purpose for which they could have been used. Air, as a substance having the power of movement, was apparently not thought of. Ventilation depended on the natural tendency of Nature to abhor a vacuum. Air penetrated the tunnels from the surface, accelerated by the strong winds which sweep over the uplands of Europe. That there was a supply of air, we know, for lamps and torches were used by these miners. At Spiennes, chunks of chalk were hollowed out to form cups probably filled with tallow in which a floating wick was placed.(2-3) Stone lamps have also been found, and probably, torches of resinous wood.(3-3) Since all these methods of illumination consisted of a naked flame, we must assume that the ventilation of these early mines was good enough to allow the miner to breathe and the lamp to burn at the same time, yet were not so draughty that the lamps would blow out. Grimes Graves, a well-known English prehistoric mine, is an example of how the air-flow must have been directed. Whether it was directed deliberately or not we cannot tell. We know that man knew how to shut out draughts; he made wind-breaks and primitive shelters at this time, but whether he applied his knowledge to directing the underground air-flow is uncertain.

The earliest scientific development of mining methods which we know about, originated in pre-dynastic Egypt, but evidence has been found, in the form of worked metal, of earlier Sumerian mining. By the first dynasty in Egypt, scientific development was well advanced. The calendar, for instance, was established, and the two kingdoms of Upper and Lower Egypt each had a complex political hierarchy and system of religious beliefs. We have evidence that, about 3400 B.C., in the time of Menes, the first dynastic ruler who united the two kingdoms, a remarkable engineering feat was accomplished. A great embankment was built, diverting the course of the Nile to form a safe site for the construction of the new capital of Memphis. If this could be accomplished, it is reasonable to assume that mining engineering was also of a high standard.

Mining operations in Egypt are first noted in the records of King Semerkhet, of the first dynasty, who exploited the copper deposits of the Wadi Maghara, in the southern part of the Sinaitic peninsula. According to inscriptions, these mines worked until the time of Rameses IX of the twentieth dynasty, a period of 2,000 years.[3-4/2-4] Miners were slaves and prisoners; they worked naked, in chains. Robust male adults broke the rock, children carried it in baskets from the face to the surface and women and old men did the hand-grinding of the ore.[2-4] Fire-setting was practised to break up the hard rock, which makes one assume that a good supply of air was available. This method of breaking rock was first referred to specifically by Agatharchides in the second century B.C. How the fumes resulting from fire-setting were carried off is not known. The ancient Egyptians did not attach much value to the lives of their slaves, and probably did not bother overmuch whether they were gassed or not.

This method of breaking rock persisted in certain German and Norwegian mines even down to the end of the nineteenth century, 270 years after the first application of explosives to mining. It was well known by the Greeks, Romans and Phoenicians - at any rate in literature. Livy (59 B.C. - 17 A.D.) was the first Greek to mention it in stories,[10] and Pliny (23 - 79 A.D.) says, "Occasionally a kind of silex is met with, which must be broken by fire and vinegar, or, as the tunnels are filled with suffocating fumes and smoke, they frequently use bruising machines, carrying 150 librae of iron.[9] (N.B. 100 librae equals one hundredweight) This shows that there was no method of carrying off the fumes at this time. Agricola says, "This myth about breaking rocks with fire and vinegar is of more than usual interest and its origin seems to be in the legend that Hannibal thus broke through the Alps.[10] Livy states that Hannibal's men set fire to the timber when a wind had arisen suitable to excite the flame, then when the rock was hot, it was eased by pouring on vinegar". Hannibal crossed the Alps in 218 B.C.[10] It was a remarkable endurance feat, but it is more than doubtful whether he actually tunnelled his way through. Most mining engineers to-day would balk at the task, even with the specialised blasting and ventilation equipment we now possess.

A possible explanation for using vinegar is that for the lack of water, Hannibal's engineers, when breaking a road for the army across the mountains, used their wine to wet the rock previously heated by the wood fires. The usual practice was to break the rock or ore by making a wood fire at the working face, the heating serving to crack or crumble the rock so that it can be broken readily by the miner's pick and gad. To

/intensify ...

intensify the effect of the fire, a douche of water is usually applied, the sudden cooling of the rock thereby causing it to crack more freely.(3-6)

For the Greek period, therefore, the most important mining enterprises were the silver mines at Laureion. The exact age of these mines is not known.(2-6) Xenophon tells us that in his day it was agreed "that the mines have been worked for many generations".(7) The Laureian miners sank over 2,000 shafts, the deepest of which was driven 386 feet into the earth, in about 500 B.C.(3-5) The main shafts were 6 ft. by 4 ft. in section. It is estimated that the rate of sinking was about 15 feet per month, a rate which would cool the ardour of the most inveterate gambler in Free State shares to-day. The miners either entered the workings by way of inclined shafts, crude stairways, or ledges cut in the perpendicular rock walls of the shaft.(3-5) It was, perhaps, fortunate, that they were not hampered by Proto gear. The underground passages or galleries were only 2 to 3 feet high and wide, just large enough to admit a modern miner but small enough to ensure that he would do no effective work.(3-5)

The problem of ventilation was a hard one, for the galleries were low and crooked. The circulation of air was promoted, however, by the use of occasional air shafts, and by duplicating the main galleries which, running parallel to each other, were connected by short cross-cuts. Fires at the bottom of the main shafts also helped to make the air circulate in the galleries,(2-7) but its heat must have made this a doubtful advantage. The atmosphere resulting from the heat, the odour of urine and perspiring bodies, and the smoke from oil-lamps must have been well-nigh unbearable. There were no sanitary arrangements,which added to the discomfort of the miners. Each miner slave was provided with a small terra-cotta lamp with sufficient oil to last ten hours, the length of his daily shift.(8) Giving an account of some of the mines in Egypt, Lethbridge(8) describes the conditions under which the miners of this period worked. "It is hard to imagine the conditions under which the poor unfortunate miners of ancient times were forced to work. The workers were almost entirely prisoners of war and criminals. The criminals often included men of standing who had, by political action or for some other reason, incurred the anger of the Pharaoh who would banish them with their whole families to the mines. These prisoners were laden with fetters by night and by day. They were brutally treated by overseers; sometimes prisoners earned some slight privilege by their very brutality to their fellows. Galleries and stopes followed the veines, twisting and turning as they went. The light disappeared within a few feet, and all workers carried lamps bound to their foreheads which seemed at variance with the old practice of using shallow hand lamps, burning oil, sometimes hung on the walls by a wire hook."(8)

Rosen(2-8) tells us that the Romans had en empirical knowledge of the hazards resulting from poor ventilation. They possessed methods for the recognition of the existence of noxious gases, such as carbon dioxide. Vitruvius, according to Rosen,(2-9) in discussing the digging of wells, pointed out that sometimes "Currents of air, which, coming up in a pregnant state through porous fissures to the places where wells are being dug and finding men engaged in digging there, stop up the breath of life of their nostrils by the natural strength of exhalation, so those who do not quickly

/escape...

FIG NO. 1. After Agricola.

SILLS OVER SHAFTS - VENTILATION EARLY 16TH CENTURY.

A. Sills.
B. Pointed Stakes.
C. Cross Beams
D. Upright Planks
E. Hollows.
F. Winds
G. Covering Disc.
H. Shafts.

escape from the spot are killed there. To guard against this, we must proceed as follows:-

> Let down a lighted lamp and if it keeps on burning, a man may make the descent without danger, but if the light is put out by the strength of the exhalations, then dig air shafts beside the well on the right and left. Thus the vapour will be carried off by the air shafts as through nostrils."(2-8)

Pliny makes reference to poisonous gases in the mines in Spain. He relates that the exhalations from the mine drifts are dangerous, particularly for dogs. This suggests a possibility that dogs may have been employed to detect the presence of noxious gases, such as carbon dioxide, which, being heavier than air, tend to collect near the floors of the levels.(2-9)

The Roman mines were deeper than those of their Greek predecessors. The deeper down the mines went, the greater became the danger for the miners. Speaking of the occupational hazards of mining, Rosen quotes Galen's personal experience during one of his (Galen's) journeys to the island of Cyprus where he spent some time inspecting the mines where copper sulphate was obtained. "The miners worked in an atmosphere of suffocating fumes, and Galen mentions that he was almost overcome by the stench. Those miners who transported the vitriolic fluid out of the mine, did so as rapidly as possible, to avoid suffocation." Galen goes on to relate that, "The miners were naked while at work, because the vitriolic fumes destroyed their clothing."(2-11)

Simple methods for the detection and prevention of noxious gases in subterranean passages were used by the Romans. Primitive respirators were also employed to avoid the inhalations of dust.(2-12)

Pliny mentions a type of respirator and says, "Those employed in the works preparing vermillion, cover their faces with a bladder skin, that they may not inhale the pernicious powder, yet they can see through the skin."(9-2)

Rosen quotes Julius Pollux (124 - 192 A.D.) as saying that, "The miners of this time covered themselves with bags and sacks or employed bladders to cover their mouths as a protection against the inhalation of dust." These are, according to Rosen, "the earliest recorded attempts at the reduction and prevention of the accidental hazards and the deleterious environmental conditions that are created in mining."

THE DARK AGES (MIDDLE AGES)

With the fall of the Western Roman Empire (A.D. 476) and the Italian Renaissance (A.D. 1500) which characterised the decay of civilization, mining records apparently vanished.

The mining industry developed in different parts of the world during the thirteenth, fourteenth and fifteenth century,

/but there...

but there are few records. The deepening of the mines produced problems of drainage and ventilation. It is not until the early sixteenth century we find reliable records on mining, and, for the subject matter of this paper, ventilation. During the Middle Ages or Medieval Period, the miner developed from a feudal serf to a free artisan. Serf labour was not entirely eradicated.

SIXTEENTH CENTURY.

The classic description of the mining industry in central Europe at the end of the Middle Ages is to be found in the works of Agricola, on which my facts are based. These works were translated from the first Latin edition of 1556 by Herbert Clark Hoover and Lou Henry Hoover in 1912.

It was not superseded as a text-book and guide to miners and metallurgists for 180 years. Until Schlüter's great work on metallurgy in 1738, it had no equal.

Geogius Agricola was born at Glauchu, in Saxony, in the year 1494. At this time, Colombus had just returned from his great discovery and three years later Vasco da Gama rounded the Cape Good Hope. Geogius Agricola's real name was George Bauer ("peasant") and it was probably Latinized by his teachers, as was the custom of the time. He died in the year 1555 at the age of 62.

Agricola describes and illustrates ventilating machines in book VI of his works. Introducing ventilating machines, he states inter alia, "If a shaft is very deep and no tunnel reaches to it or no drift from another shaft connects with it, or where a tunnel is of great length and no shaft reaches to it, then the air does not replenish itself. In such a case it weighs heavily on miners, causing them to breathe with difficulty and sometimes they are even suffocated, and burning lamps are also extinguished. There is therefore a necessity for machines which the Latins call Spiritales - though they do not give forth any sound - which enable the miners to breathe easily and carry on their work."(10-1) These ventilating machines or devices are of three genera. The first receives and diverts into the shaft the blowing of the wind and this genus is divided into three species of which the first is as follows:-

First Genera: Species 1 (See Fig. No. 1)

"Over the shaft, to which no tunnel connects, are placed three sills a little longer than the shaft - the first over the front, the second over the middle and the third over the back of the shaft. Their ends have openings through which pegs, sharpened at the bottom, are driven deeply into the ground so as to hold them immovable, in the same way that the sills of a windlass are fixed. Each of these sills are morticed into each of the three cross-beams of which one is at the right side of the shaft - planks are fitted which are joined in such a manner that the one which preceded always fits into the groove of the one that follows. In this way four angles and the same number of intervening hollows are created which collect the winds that blow from all directions. The planks are roofed above with a cover made in a circular shape, and are open below, in order that the wind may not be diverted upward

/and escape,...

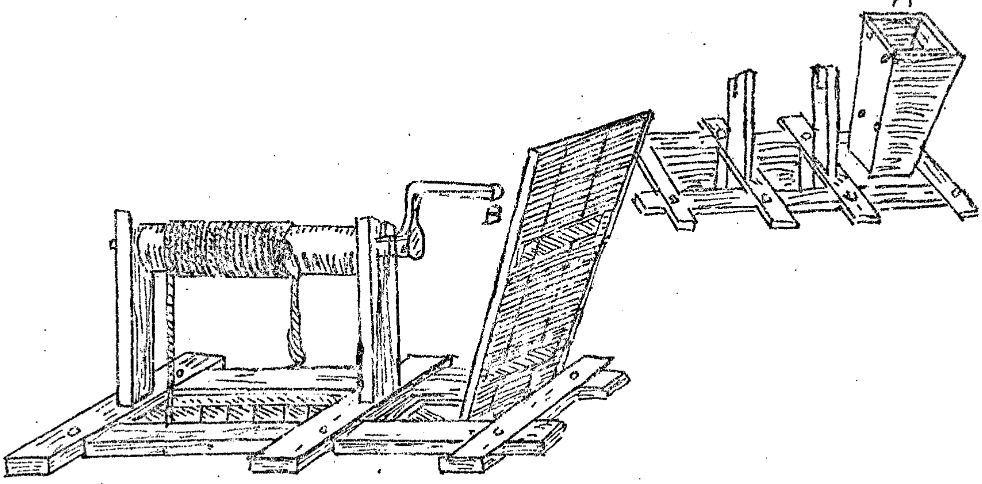
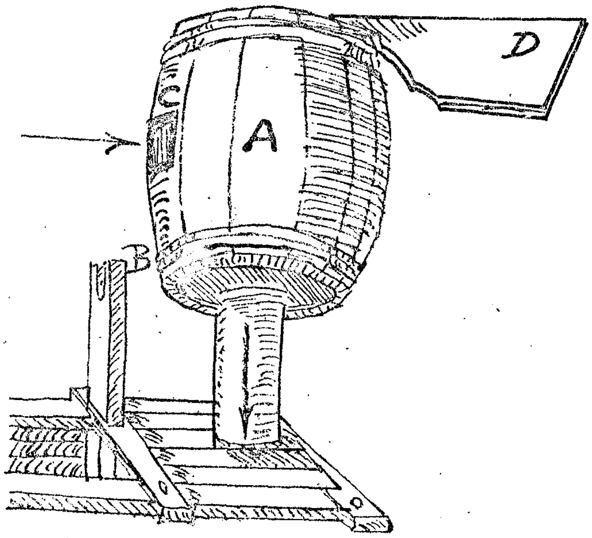


FIG. NO. 2. After Agricola.

BLOWING AIR INTO SHAFT THROUGH BOX-SHAPED CONDUIT - VENTILATION EARLY 16TH CENTURY.

A. Projecting Mouth of Conduit.

b. Planks fixed to the Mouth of the Conduit which does not project.



BARREL VENTILATOR.

FIG. NO. 3. After Agricola.

BARREL VENTILATOR - EARLY 16TH CENTURY.

A. Wooden Barrel. C. Blow-Hole.

B. Hoops. D. Wing.

and escape, but may be carried downward, and thereby the winds of necessity blow into the shafts through the four openings. However, there is no need to roof this kind of machine in those localities in which it can be so placed that the wind can blow down through its topmost part."(10-1)

"The second machine of this genus (See Fig. 2) turns the blowing wind into the shaft through a long box conduit, which is made of as many lengths of planks joined together, as the depth of the shaft requires. The joints are smeared with fat, glutinous clay, moistened with water. The mouth of this conduit either projects out of the shaft to a length of three or four feet, or it does not project. If it projects, it is shaped like a rectangular funnel, broader and wider at the top than the conduit itself, that it may the more easily gather the wind. If it does not project, it is not broader than the conduit, but planks are fixed to it away from the direction in which the wind is blowing, which catch the wind and force it into the conduit."

"The third of this genus of machine is made of a pipe or pipes and a barrel (See Fig 3). Above the uppermost pipe there is erected a wooden barrel, four feet high and three feet in diameter, bound with wooden hoops. It has a square blow-hole always open, which catches the breezes and guides them down either by a pipe into the conduit, or by many pipes into the shaft. To the top of the upper pipe is attached a circular table as thick as the bottom of the barrel, but of a little less diameter, so that the barrel may be turned around on it. The pipe projects out of the table and is fixed in a round opening in the centre of the bottom of the barrel. To the end of the pipe a perpendicular axle is fixed which runs through the centre of the barrel into a hole in the cover, in which it is fastened in the same way as at the bottom. Around this fixed axle and the table on the pipe, the movable barrel is easily turned by a zephyr, or much more by a wind, which govern the wing on it. The wing is made of thin boards and fixed to the upper part of the barrel on the side furthest away from the blow-hole; this, as I have said, is square and is always open. The wind from whatever quarters of the world it blows, drives the wing straight toward the opposite direction, in which way the barrel turns the blow-hole towards the wind itself; the blow-hole receives the wind, and it is guided down into the shaft by means of the conduit or pipes.(10-1)

Agricola then describes a blowing machine made with fans of varied and many forms for the fans are either fitted to a windlass barrel or to an axle (See Fig. 4). "If to an axle, they are either contained in a hollow drum, which is made of two wheels and a number of boards joining them together, or else in a box shaped casing. The drum is stationary and closed on the sides, except for the round holes of such size that the axle may turn in them; it has two square blow-holes of which the upper one receives the air while the lower one empties into the conduitby which the air is led down the shaft. The ends of the axle, which project on each side of the drum, are supported by forked posts or hollowed beams plated with thick iron; one end of the axle has a crank, while in the other end are fixed four rods with thick heavy ends, so that they weight the axle and, when turned, make it prone to motions as

/it revolves, ...

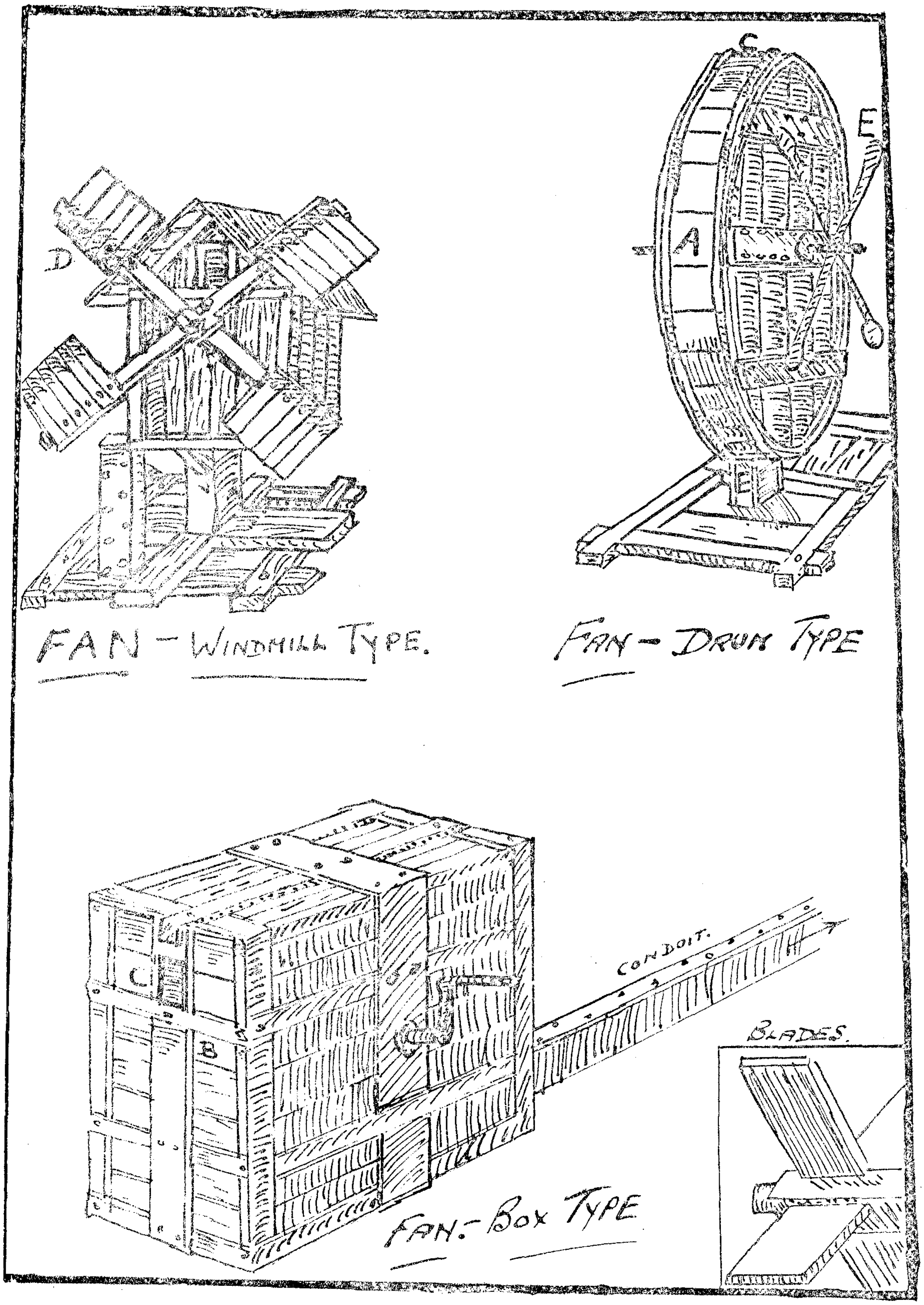


FIG. NO. 4.

After Agricola.

BLOWING MACHINES (FANS) - EARLY 16TH CENTURY.

A. Drum.

C. Blow-Hole.

B. Box-shaped Casing.

D. Sails.

E. Rods.

it revolves, and so when the workman turns the axle by the crank, the fans draw in the air by the blow-hole and force it through the other blow-hole which leads to the conduit, and through this conduit the air penetrates into the shaft." (10-12)

"The one with the boxed-shaped casing is furnished with the same things as the drum, but the drum is far superior to the box, for the fans so fill the drum that they almost touch it on every side and drive into the conduit all the air that has been accumulated; but they cannot thus fill the box shaped casing on account of its angles into which the air partly retreats; therefore, it cannot be as useful as the drum. The kind with the box-shaped casing is not only placed on the ground, but is also set up on timbers like a windmill, and its axle, in place of a crank, has four sails outside; like the sails of a windmill."

"When these are struck by the wind, they turn the axle; and in this way its fans - which are placed within the casing - drive the air through the blow-hole and the conduit into the shaft. Although this machine has no need for men - whom it is necessary to pay to work the crank - still when the sky is devoid of wind, as it often is, the machine does not turn, and it is therefore less suitable than the others for ventilating a shaft." (10-2)

In the kind where the fans are fixed to an axle, there is generally a hollow stationary drum at one end of the axle, and on the other end is fixed a drum made of rundles. This rundle drum is turned by the toothed wheel of a lower axle, which is itself turned by a wheel whose buckets receive the impetus of water. If the locality supplies an abundance of water, this machine is most useful, because to turn the crank does not need men who require pay, and because it forces air without cessation through the conduit of the shaft." (10-3)

Another form of blowing machine, described by Agricola, is the type made with bellows. Bellows are of very ancient origin, about 1500 B.C. (10-9) Agricola states, "By the blasts of these blowing machines, made with bellows, the shafts and tunnels are not only furnished with air through conduits or pipes, but they can also be cleared by suction of their heavy and pestilential vapours".

"There are two different machines for operating bellows by means of horses." "A horse is kept continually within bars, like those within which horses are held to be shod with iron, and by treading steps with its feet it turns the wheel, together with the axle; the cams on the axle press down the sweeps which compress the bellows." (10-4) The instrument or machine is made in such a manner as to raise the bellows so that they are again compressed.

The second machine operated by horses is described as "the upright one is turned by a horse and its toothed drum turns a drum made of rundles on a horizontal axle; in other respects this machine is like the last. Here, also, the nozzles of the bellows placed in the conduits blow a blast into the shaft or tunnel".

/In the same...

"In the same way that this last machine can refresh the heavy air of a shaft or tunnel, so also could the old system of ventilating by the constant shaking of linen cloths which Pliny has explained; the air not only grows heavier with the depth of the shaft, of which fact he has made mention, but also with the length of the tunnel." (10-4)

Speaking of the ailments and accidents of miners and of the methods by which they can guard against these, Agricola says, "We should always devote more care to maintaining our health, that we may freely perform our bodily functions, than to making profits. Of the illnesses, some affect the joints, others attack the lungs, some the eyes, and finally some are fatal to men". (10-5)

"Where water in shafts is abundant and very cold, it frequently injures the limbs, for cold is harmful to the sinews. To meet this, miners should make themselves sufficiently high boots of rawhide, which protects their legs from the cold water; the man who does not follow this advice will suffer much ill-health, especially when he reaches old age. (10-5) On the other hand, some mines are so dry that they are entirely devoid of water, and this dryness causes the workmen even greater harm, for the dust, which is stirred and beaten up by digging penetrates into the windpipe and lungs, and produces difficulty in breathing." "If the dust has corrosive qualities, it eats away the lungs, and implants consumption in the body; hence in the mine of the Carpathian mountains women are found who have married seven husbands, all of whom this terrible consumption has carried off to a premature death."

"At Altenberg in Meissen there is found in the mines black Pompholyx which eats wounds and ulcers to the bone; this also corrodes iron, for which reason the keys of their sheds are made of wood.

"Further there is a certain kind of Cadmia which eats away the feet of workmen when they have become wet, and similarly their hands, and injures their lungs and eyes. Therefore, for their digging they should make for themselves not only boots of rawhide, but gloves long enough to reach to the elbow, and they should fasten loose veils over their faces; the dust will then neither be drawn through these into their windpipes, nor will it fly into their eyes. (10-5)

"Stagnant air, both that which remains in a shaft and that which remains in a tunnel, produces a difficulty in breathing; the remedies for this evil are the ventilating machines."

"There is another illness even more destructive, which soon brings death to men who work in those shafts or levels or tunnels, in which hand rock is broken by fire. Here the air is infected with poison, since large and small veins and seams in the rocks exhale some subtle poison from the minerals, which is driven out by the fire, and this poison

/itself...

itself is raised with the smoke not unlike pompholyx which clings to the upper part of the walls in the works in which it is smelted." (Authors note (Hoover) - Pompholyx was a furnace deposit, usually mostly zinc oxyde, but often containing arsenical-oxide, and to this latter quality this reference probably applies). (10-6)

Agricola then refers to fire setting stating that, "Prudent and skilled miners burn the piles of wood on Friday, towards evening, and they do not descend into the shafts nor enter the tunnels again before Monday, and in the meantime the poisonous fumes pass away." There are also times when a reckoning has to be made with Orcus (the god of infernal regions - otherwise Pluto) for some metalliferous localities, though such are rare, spontaneously produce poison and exhale pestilential vapour, as is also the case with some openings in the ore; though these more often contain noxious fumes."

Agricola describes a venomous ant which exists in Sardinia. "This animal is as Solinus writes, very small and like a spider in shape (this refers to a scorpion), it creeps unobserved and brings destruction upon those who imprudently sit on it." (10-7)

Agricola writes of "demons of ferocious aspect" - that are expelled and put to flight by prayer and fasting" (Author's note (Hoover) "The presence of demons or gnomes in the mines was so general a belief that Agricola fully accepted it.). Agricola in his book "De Animantibus Subterraneis" writes about these demons :- "Then there are the gentle kind which the Germans as well as the Greeks call Cobalos because they mimic men. They are called little miners because of their dwarfish stature which is about two feet. They are venerable looking and are clothed like miners in a filleted garment with a leather apron about their loins. This kind does not often trouble miners, but they idle about in the shafts, and tunnels, and really do nothing, although they pretend to be busy in all kinds of labour, sometimes digging ore, and sometimes putting into buckets that which has been dug."

"Sometimes, they throw pebbles at the workmen, but they rarely injure them unless the workmen first ridicule or curse them. They are not very dissimilar to goblins which occasionally appear to men where they go to or from their days work, or when they attend their cattle; because they generally appear benign to men, the Germans call them guteli." (10-8)

Author's note : "The German miners were not alone in their beliefs, for miners generally accepted them, even to-day the faith in "knockers" has not entirely disappeared from Cornwall. Neither the sea nor the forest so lends itself to the substantiation of the supernatural as does the mine. The dead darkness, in which the miners' lamps serve only to distort every shape, the uncanny noises of restless rocks whose support has been undermined, the approach of danger and death without warning, the sudden vanishing or discovery of good fortune, all yield a thousand corroborations to minds long steeped in ignorance and prepared for the miraculous through religious teaching." (10-8)

(This address will be continued in the August issue)