Fan Ventilation.

T. B. BANCROFT.

READ AT IRONTON MEETING.

Mechanical methods of ventilation have been employed in mines, to a greater or less extent, for more than two hundred years. Fans were in use in Germany in the seventeenth century, but it is only within the last thirty years that centrifugal ventilation has been before the public in such shape as to conform to the requirements of modern mining. James Naysmith, a Scotch engineer, built a fan and used it in mine ventilation sometime during the first half of the present century. I have been unable to discover the exact date of this occurrence, but believe it to have been prior to 1849, in which year Brunton exhibited drawings, and explained the workings of a centrifugal fan of his own designing to a committee of the House of Lords. In 1861 Mr. Atkinson described, to the North of England Institute of Mining Engineers, a centrifugal fan then in operation, and bore his testimony to the vast superiority of this method of ventilation over any other then in use. At about this time, or perhaps a little later, fans began to be used among the anthracite mines of Pennsylvania. The adoption of this mode of ventilation has since been rapid, and the results have proven the wisdom of the change. Wherever the centrifugal fan has been once used, a return to the furnace as a means of ventilation has seldom, if ever, been noticed.

ADVANTAGES OF THE FAN.

Ventilating fans, with engine, are now built and sold at so near the cost of a first-class furnace, that it is unnecessary to consider the item of first cost when comparing the relative merits of the fan and furnace. In fact, it will be found that a furnace equal to the *full* capacity of a fan of any given size would cost as much, or more than the fan would. It is generally conceded that the fan is the more economical in shallow mines, but what it loses in point of economy in deep mines is more than counterbalanced by the danger from the furnace in such mines, which, as a rule, produce more explosive gas than the shallower ones. So far as the mines of Ohio are concerned (and in fact the coal mines so far as developed in the United States), there are none that can be properly termed "deep." Admitting this to be the case, we may proceed to consider the advantages of the fan over the furnace without reference to the depth of the mine as a factor in the calculation.

In the matter of expense attending the cost of running, the fan has a decided advantage over the furnace. In most shaft mines the air shaft is so located that steam can be carried to the fan from the hoisting boilers, and the employment of a special attendant may be dispensed with. The steam pressure upon the fan engine can be regulated, or if desired, a governor can be placed upon the engine, and the fan will run along without attention, other than the ordinary lubricating, which can be attended to by the fireman at the hoisting boilers, at no extra expense to the operator. In such cases, the coal consumed in running the fan becomes merely nominal, and is hardly appreciable in the general expense. Should the location of the fan be such as to render necessary the employment of a special boiler and attendant, the fan still has the advantage of the furnace in the cost of coal. What this cost may be in our own State, in the absence of any tests made, cannot be given with any certainty. Experiments made in Scotland show the amount of coal required to obtain a given volume of air to be in the following ratio:

By steam jet	1,000
By furnace	350
By open, running fans	150
By Guibal principle	120

From this table it is evident that the economy in cost of coal alone over the furnace is more than sufficient to warrant the change from it to the fan, and it must also be remembered that these figures relate to fans supplied with steam from boilers of their own and not from hoisting boilers, so that the full complement of coal required to run them under any circumstances entered into the calculation. The experience of the Hollingwood pits, in England, will answer to demonstrate the saving in ordinary running expenses in that country, and may be considered generally applicable to similar cases elsewhere. These pits were ventilated by two furnaces of 12.63 horse power, moving 78,588 cubic feet of air per minute through the mine. A Guibal fan was erected to take the place of the two furnaces, which, at sixty revolutions per minute, moved 106,680 cubic feet of air in the same time. The difference in favor of the fan was found to be as follows:

Cubic feet of air per minute, increase	28,092
Pressure in pounds per square foot, increase	9,256
Horse-power in air (including shaft friction), increase	34.43
Cost of fuel and wages in 24 hours, decrease	$5.11
Cost of horse-power in air, for 24 hours, decrease.	.70
Pounds of coal per horse-power of air, per hour, decrease	.39

and the amount saved in one year by the fan was $2,120.65. The size of this fan is not given, nor does it affect the fact that an increased capacity, with a corresponding decrease in cost, accompanied its substitution for the two furnaces.

The saving in the running expense of the fan is by no means the most important advantage it possesses. It is the part of good mine management to have a surplus of ventilating power on hand at all times, to be used in case of emergency. A furnace may be largely in excess of the demands upon it when erected, but the gradual development of the mine will eventually eome up to, and even exceed, its capacity. Nothing then remains but to tear out and enlarge the furnace. Should occasion require an increased ventilation, and the furnace capacity admit of it, it can only be had by increasing the fire area, a slow process even where all that is required is to make more fire, or spread it over idle grate bars. The fan always possesses a reserve of power, which can be brought out and utilized instantly by simply giving it more steam and increasing its speed, and, as a general rule, it may be said that the capacity of the fan for passing air is only limited by the size of the mine air courses, because of its possibilities by the increase of speed.

The furnace is affected in its operations by changes in the temperature of the atmosphere on the surface, which sometimes are sudden and extreme, and the air current must vacillate in accordance with these changes. The furnace requires constant attention on the part of the fireman, who is much of his time in the foul air collected from all parts of the mine, and his energies cannot but be affected at times from this cause. The momentum of a body of air in motion assists the motive power to a great extent. With the furnace the velocity and amount of air obtained depends upon the attention of the fireman to his duties, and should he neglect them the velocity decreases, and the amount passing is lessened, causing an expenditure of more power, and a delay in bringing the body of air back to its original volume and speed, while the men employed in the mine suffer the consequence of his neglect. The fan is subjeet to none of these fluctuations. It is not directly affected by atmospheric changes, nor does the volume of its current vary or its speed change, but a steady and constant stream of air flows through the air courses, subject only to the regulation of its revolutions.

When a fan is in use, the air-shaft, not having to carry off the gases from a furnace fire, with a ladder or stairway in it, is always open, and affords a sure and quick means of escape for the miners in the event of a sudden explosion of gas, or influx of water. If the fan be reversible (and all fans should be) its motion could, in case of fire among the buildings on top of the downcast, in a few minutes be reversed, and the stythe from the fire be expelled from, instead of being drawn into the mine passages to the suffocation of the men met in its course. In the writer's experience, after an explosion of gas, forty men were brought out unconscious from the effects of the after-damp, and four others were dead when found. Had the fan been reversible it is believed that this calamity would not have been so great, and might have been altogether avoided. In fiery mines, danger exists from the gas coming in contact with the fire of the furnace, and causing an explosion. Even in Ohio, whose mines are most singularly free from fire-damp, Mr. Roy, in his report for 1874, mentions an explosion in Rush Run shaft, Jefferson county, and says: "So abundantly had the fire-damp accumulated that it returned to the furnace undiluted by the fresh, newly-introduced air, and in passing over the fire exploded with great force, dashing out the wood-work of the shaft, and throwing it out of the pit's mouth. The earth shook with the force of the explosion. The mine was set on fire, and descent was made impossible," etc. It is to be presumed that in this case the furnace was destroyed, as Mr. Roy states that other means of ventilation had to be resorted to before the mine could be entered, and the regular ventilation be resumed. An accident from this cause could not have occurred had a fan been in use at this shaft. Had as violent an explosion occurred from other causes, the fan could have been so placed as to have been safe from the shock, and even had it been injured it could have been reached and repaired, and when ready could have been started, and the managers could have followed the current of fresh air from the downcast, erecting brattices and stoppings where necessary, and bringing the ventilation back to its original course and condition in comparative safety, and in much less time than if they had to grope about in the dark, as to what course the air might take at the next hole, or wh re they might suddenly enter upon another accumulation of gas, or after-damp, as the case might be. The length of this paper will not permit further arguments in favor of the fan, and while all its merits have by no means been enumerated, we will pass to the consideration of

THE GUIBAL FAN.

There are several different styles of fans, each of which have their advocates. Practice and the general opinion of mining engineers has, however, given fans of the Guibal type the preference, and the majority of those now in operation are of this class. They are simple in construction and not liable to get out of order, and practically from 60 to 65 per cent. of the power generated to run them is utilized in ventilating, the balance being consumed in overcoming the friction and in covering losses by leakage, etc. The Guibal fan proper consists of a number of vanes, inclining backwards and attached to a shaft, which revolve in a spiral casing, receiving the air through open spaces in the sides, and discharging it through an opening in the periphery, by way of an expanding chimney. The discharge opening is furnished with a shutter, by which its area can be increased or lessened, as circumstances may require. This fan, with modifications to suit the views of engineers or builders, is the one in general use at present. The different views of engineers relate to details of construction in the angle of the vanes, size of openings, character of chimney, length of spiral, open or closed casing, etc. The idea is advanced by some that a casing entirely open in its periphery is the best, as it permits of the free discharge of the air at all points. Others prefer a chimney of constant area instead of an expanding one. M. Murgue, a French engineer, has made numerous experiments with a view of discovering the best practical form, and relative size of the parts, of a centrifugal fan. His conclusion is that the Guibal fan is superior to all others. In his researches he collected data of the size, shape, and effective results of 58 fans of different types and construction. The following table gives the comparative useful results of these fans:

For ventilators without cover........	.327
Covered, and without chimney..................	.560
Covered, and with rectangular chimney.........	.606
Covered, and with expanding chimney..........	.650

and he adds, "the approximate manometric results in our table permit us to estimate at .750 the actual manometrical yield of a well-made Guibal machine." This would indicate that in such a fan only twenty-five per cent. of the power applied is lost to the purpose of ventilation. M. Guibal himself claims for his fan,

Without casing, a useful effect of..........	22 per cent.
With casing, a useful effect of.............	31 per cent.
With casing, and expanding chimney......	57 per cent.
With casing, and shutter adjusted..........	61 per cent.

It will be noticed in the above a claim is made of twenty-six per cent. for a fan with expanding chimney over one without, and this is further increased four per cent. by the use of the adjustable shutter.

FAULTY CONSTRUCTION OF SOME FANS.

The introduction of fans as ventilators in mines west of the Alleghenies has been of recent date, and the results in many cases have not proved to be what was expected by their builders. Hence we sometimes hear it said that the furnace did better than the fan that has taken its place. These fans have been mostly constructed on ideas of manufacturers who have no practical knowledge of the requirements in mine ventilation, and follow only their own crude notions. In fact but few of the fans in use in Ohio are constructed with any regard to the principles involved, or to the rules governing centrifugal ventilators. Many of them display utter absence of knowledge of even the rudiments of atmospheric laws. A fan, made by the bank boss, came under my notice, in which the arms of the spider were made of 4 by 4 scantling. This fan answered the purposes of the mine, but the maker never noticed that the arms (one on each side for every vane) nearly closed the inlet to the fan by reason of their thickness. Another was set directly in the mouth of the air shaft, closing up and lessening the capacity of the air course by nearly two-thirds. Many fans are sent out from the shop with directions and drawings showing how the wooden casing should be built around them. This casing is built by a carpenter, perhaps entirely competent in his line, but with no knowledge of what a fan should be. The result is faulty construction and imperfect work in the ventilator. Wooden casings are to be condemned in any case, as they are liable to warp and crack, causing leakage and great waste of power, but when to this is added the blunders of construction in the hands of an incompetent person, it is simply wonderful that any better results are obtained than were got by the furnace. Of these cases I have noticed one in which the carpenter had put the side of the casing at least four inches from the blades, thus giving ample room on the inside for a current counter to the blades, and, while increasing the friction and power required to run the fan, decreasing in a serious degree its effective service. Another had the discharge opening too wide, allowing an in-draft against the blades. Complaint was made that the fan was not doing as well as the furnace. Closing the discharge about one-half, increased the current 3,600 feet per minute. But in this case the fan was actually discharging downward, or towards the ground. Discharging rarified air downward against the more dense air of the surface! Throwing a cork into water and expecting it to sink! Yet all these cases followed the instructions for making the casing sent with the fan. Fans are made with the intake on the one side only. A clear infraction of the first principles of their construction. The revolution of the vanes causes a vacuum into which the air rushes from the mine. If one side of the fan be closed it destroys the usefulness of nearly one-half its area, and a conical body of stagnant air stands upon the closed side, obstructing the passage of the incoming air and acting as a drag upon the vanes; for the air rushing in from the open side is caught up by the vanes and passed out at the discharge before it can penetrate to the other side of the casing. Again, fans are made without the spiral in the casing, which all conversant with the matter know to be of the highest importance to their economical working. Others are made with the spiral and intended to be reversible. These fans stand over the air shaft, and when used as an exhaust the air is discharged upward through an opening in the front of the casing. If it is desired to reverse the current this discharge hole is closed, and another, on the bottom directly over the shaft, is opened. By a system of doors the air then passes into the fan from the surface and is forced down the air shaft. Yet these fans do not work equally well either way. The cause is to be found in the spiral, which, from being in other cases beneficial, is in the present harmful. The spiral is made by commencing at some point a distance from the discharge and gradually enlarging the diameter of the casing until it is widest at the discharging point. This allows for the compression of the air by the vanes and facilitates its passage to the outlet. But in the fans under consideration the casing is immovable, and when one discharge hole is closed and another opened the casing is widest where it should be the narrowest, and the beneficial effects of the spiral, when discharging at one of the openings are entirely lost, and the whole internal economy of the casing is revolutionized in the attempt to reverse the action. These fans work best when discharging at the hole where the spiral is widest, and for this reason they are found to work one way better than another, as the case may be. In the west most mine managers desire a reversible fan, and the only way by which a fan of this type can be reversed, preserving its lines and proportions without waste of power and decrease in capacity, is by reversing the casing and leaving the vanes to run in the same direction, whether acting as an exhaust or as a forcer.

UPCAST AND DOWNCAST FANS.

Authorities differ as to the relative merits of the exhaust and forcing fan. It is maintained by some that the rarified air passing out of the exhaust, or upcast fan, assists, by its lesser specific gravity, and by its velocity, the action of the fan ; others claim that a loss of power results from the same cause, in that the rarified air is projected at great velocity against the denser atmosphere of the surface. The latter argument does not avail, however, where the expanding chimney is used with the fan, as will be noticed further on. Hopton, in his "Conversations on Mines," gives his opinion that the volume of air produced by an upcast and downcast would be equal, but claims there is more danger in fiery mines with the upcast. He says that were an airway suddenly closed up, by a fall or other cause, the action of the upcast would be to exhaust the air and relieve the pressure upon the pent up gas, allowing it freer vent whereby an explosion might occur. Whereas, were a downcast fan employed, it would continue to force air into the mine and thus, by increasing the pressure, prevent the escape of gas. The weight of this argument would seem to depend upon which side of the fall the most gas existed.

One benefit to be derived from the downcast in shaft mines is that in winter time the warm air from the mine ascending the hoisting shaft, serves to keep the guides and cages from freezing, and to this extent facilitates the hoisting operations at that season of the year. One very serious objection to the downcast fan, however, is to be found in the fact that the return air of the mine is carried out by way of the entries, or most traveled routes, to the detriment of men and teams using the same, and in fiery mines the gas collected by the air currents, and passing this way and up the hoisting shaft, would increase the danger from explosion. Much can be said in favor of either plan, but it is questionable whether a satisfactory decision can be reached on the subject. The fact remains, however, that most fans in operation are upcasts. Especially is this the case among the gaseous mines of the anthracite region, where the upcast is used entirely. The same is true of English mines and those of the continent, and it is well to remember in this connection that these mines require larger bodies of air than our western mines; their fans vary in size from 20 to 50 feet in diameter, moving as high as 250,000 cubic feet of air per minute. Their casings are built up around them in solid masonry, and the cost of the fan and its equipment is often more than would suffice to open and put in good running order any of our western mines.

REQUISITES FOR GOOD RESULTS.

Before considering the form and proportions of a good fan it will be well to glance at some conditions requisite to insure its perfect working and develop its full power. The size and character of the airways have much to do with the successful working of the fan. If the air passages are too small to admit of a quantity of air passing to the fan that will equal its capacity, a loss of volume must ensue, and consequently a waste of power and an unnecessary wear and tear. In other words the result would not be up to what the expenditure of power would warrant. This could be obviated by lessening the speed of the fan, but in that case the ventilation might not be equal to the mine requirements. For this reason the same fan may not work as well at one mine as it would at another, simply because it cannot develop its capacity, where the intake is throttled by narrow airways, or the friction is increased by their crookedness and by obstructions that have accumulated in them. In fact an inferior fan with favorable surroundings may sometimes do better than a perfect one with these difficulties to contend against.

The volume of air delivered by a fan varies as the speed of the tips of the vanes, the vacuum, depression, or water gauge, as the square of this speed. Yet where the air passages are too small for the fan we find the anomaly of an increased speed accompanied by a decreased volume. This is because the fan has not work enough to do; is not receiving air enough for its capacity, and much of the air received by it is revolving uselessly in the fan. Its power being thus in excess of air delivered to it, the speed is increased without a corresponding increase in volume. Again, were the air from the mine suddenly cut off from a fan and the surface air freely admitted to it, the speed would decrease but the volume would increase, for the reason that the fan would then have an inflow of air in excess of its capacity sufficient to lessen its speed, but would at the same time be working to its full capacity *at that speed.* Hence a full flow of air to the fan insures the maximum volume with the minimum speed. The airway eading to the fan should not be less in area than the combined area of inlets to the fan; and if made one-fourth larger, the effect would be beneficial in reducing the velocity of the upcast current and lessening the friction to be overcome. An instance is given, on good authority, where a fan running at the one speed increased its volume from 23,000 to 60,000 feet per minute when the air-ways were enlarged.

On the other hand a poorly designed fan, or one of faulty construction and proportions, may sometimes prove detrimental to ventilation because of its own inability to pass the quantity of air delivered to it by the air courses.

A fan should not be placed immediately over the air shaft. It should properly be at one side of the shaft, so that when acting as an upcast no impediment is offered to the free egress of the air from the mine to the full capacity of the shaft, and yet close enough to it so that when the casing is reversed and the fan is to run as a downcast, the mouth of the discharge opening shall come exactly over the mouth of the shaft. If, however, the conditions require the fan to be directly over the shaft, it should be placed at such a height above the shaft as not to interfere with the current flowing from the mine, and the connection between the mouth of the shaft and the fan inlets should be of somewhat larger area than the shaft itself.

In the case of an upcast fan, any obstruction in front of the outlet will retard the projection of the air and lessen the capacity of the fan. High winds blowing against the discharge of an upcast fan will also obstruct the current, even when the expanding chimney is used, and care should be taken to have the discharge outlet so located that surrounding buildings, or the topography of the land, be not such as will direct the atmospheric currents toward it. To sum up, the conditions for successful working are a sufficient area and clear passage for the air from the mine, and an unobstructed discharge from the fan.

PROPER CONSTRUCTION OF THE FAN.

The coal mines of the West do not require such large fans as are used in the anthracite mines, or in the mines of Europe, but they require them to be reversible readily, and to work equally well as an upcast or downcast. A fan of ten feet in diameter, properly constructed and under favorable conditions for developing its capacity, will be amply sufficient for the requirements of almost any of these mines. In constructing a fan, however, it is well to consider the future needs of the mine consequent upon its development, and to bear in mind, the fact that an increase in diameter adds but little to the first cost and increases its capacity as the square of the diameter. That is to say, that the comparative difference between the capacity of an eight foot fan and a ten-foot one would be as 64 is to 100. A fan properly should be constructed to conform to the special circumstances and conditions of the mine to which it is to be applied. This involves more or less experiment, which is expensive, and which, in the hands of one not fully conversant with the subject, would as likely prove detrimental as serviceable to the object in view. A general form of fan, correct in its proportions, and capable of being made to conform so closely to the varying conditions of different mines as to practically meet the needs of any one of them, would suit the views of mine owners, and would take the place of many designs now in use, some of which are built by rule of thumb, and whose strongest recommendation is that they are cheap.

We will now consider the form, proportions, and details of such a fan. In the first place, the fan should be entirely of iron, the casing and vanes of sheet iron, the former heavy enough to secure stability, and the latter light enough to be easily moved, with due regard to strength. Apart from the fact that a wooden casing is not readily reversible, it is liable to shrink and crack, causing it to leak, and thus not only to decrease the effective work of the fan, but also to cause a waste of power and an increase in wear and tear. An iron casing, made at the factory, comes to the mine in its proper shape and proportions, and is not dependent upon the knowledge of a carpenter to set up properly. All that is necessary is to have the fan shaft in the center of the inlet, and its lines and proportions are secured. Wooden vanes are also liable to warp and crack, the shrinkage throwing them out of line, and the cracks permitting the air to pass through them, both of which militate against perfect work, while the vanes, being necessarily thicker than if made of iron, take up that much more room that should be occupied by air. The power required to drive a fan is, first, that needed to overcome the friction and run the machine; and, secondly, that necessary to move the volume of air with the required velocity. Hence, the less friction we have to overcome the more power we have to apply to ventilation. For this reason the fan wheel should be light, and the thickness of the shaft as small as possible consistent with safety. The journals should be long and kept in true line with each other. The engine should be connected directly with the fan shaft. Much extra friction is caused by an engine working on a separate shaft, which is further increased by the weight of the belt and belt pulleys, and a fan run with a belt can not work as well as with a direct acting engine, as the belt will slip more or less, causing a loss in the fan economy. The casing should be made in a spiral form—that is to say, that the tips of the vanes should run close to the rim of the casing for a certain distance, and then the rim should gradually leave the tips until, at the outlet, the casings should be farthest from the vanes. Opinions differ as to where this spiral or eccentricity should commence. Some think that it should comprise the whole circumference of the casing; others three-fourths; while others again hold that one-half is sufficient. My own opinion, based upon both experiment and practice, is that the best results are obtained by carrying the periphery of the casing close to the vanes up to a point opposite the lowest part of the fan (I refer to the fan when standing in position as an upcast) and there commencing the enlargement and carrying it gradually, in an ever-widening spiral, until it reaches the discharge outlet, where the casing should be a distance from the tips of the vanes equal to one-tenth the diameter of the fan. The spiral is intended to allow gradually increasing room for the increased compression of the air, and to facilitate its passage to the discharge by enlarging the avenue of exit. If it be too short, thumping will occur, caused by the air jumping from one vane back to another, owing to lack of room for its movement. When this thumping is heard in a fan it will be safe to extend the spiral further back from the outlet. From what has been said it can now readily be seen that if a fan with a spiral casing be reversed by simply closing the exhaust opening and opening another over and into the shaft, in the expectation of as useful effect as a downcast, it cannot possibly be the case, because we then subvert the whole interior lines of the casing and have the vanes revolving in an irregular almost egg-shaped box, in entire disregard of all rules. Hence, the only proper way to reverse a fan and preserve its economy is to turn the casing over and place the mouth of the discharge in connection with the mouth of the shaft. This cannot be as readily done with a wooden as with an iron casing, because the wooden casing is too cumbersome, and must be fast to the ground to insure stability. The sides of the casing should stand as close to the sides of the vanes as possible, so that no useless air may encumber the operations, or be a drag upon the machine.

The vanes may be of any number, sufficient for their purpose, but if numerous they will be found to guide the air better and shake less than where fewer are used. Eight vanes will be the proper number for a fan such as we are describing. Much discussion has been had by mining engineers over the angle at which they should stand, and they have been set straight, inclining backward, curved backward, and inclining backward with the tips curved forward. It would seem that vanes inclining backward would necessarily be larger and heavier than straight blades, and to this extent would certainly increase the friction, while a blade with a forward curve on the tip would prevent the air from leaving the vane freely, as an upturned edge on a shovel would hinder material being thrown from it. M. Murgue, before referred to, after a series of experiments, extending over years, gives his opinion that the best form of vane is one that "begins at the circumference of the inlet with an inclination to enable it to receive the air without shock, extending upward with a gentle curve, and ending in a line following the radius." That is to say, a straight blade curved at the bottom in the direction in which the fan runs.

In support of the straight blade it may be said that in the early Guibal fans the vanes inclined backward, but subsequently the inventor himself adopted the straight blade in preference.

As to the width of the vanes, it is found that any increase beyond a certain point is productive of no benefit, and is a waste of power. Where this point is can only be determined by experiment, but it is a fact that most of our fans are wider in the vane than necessary, and would produce the same results if narrower. Experience teaches that a width equal to one-fourth the diameter of the fan will generally be found most suitable, while the length is regulated by the size of the inlet, which *should be one-half the fan diameter*, and, as the vanes should not extend beyond the circumference of the inlet, their length will necessarily be one-fourth the fan diameter, or, in other words, the vanes should be square.

The size of the inlet, I have said above, should be one-half the diameter of the fan. What the *exact* size of this opening should be has never yet been determined by experiment, and most European fans have inlets of rather less diameter than given above, but in the construction of a fan for general service it will be found that the above size will meet all requirements where the shutter, yet to be noticed, is used.

The exact size of the outlet can only be determined by experiment, as it depends greatly upon the thickness of the seam worked and the size of the airways. It should be large for thick veins and high airways, and smaller for thin seams where the airways are lower. It should be regulated to the capacity of the fan and the width and eccentricity of the casing, as well as the size of the inlet, have bearing upon this question. If the outlet be too large air re-enters the fan in a sort of back current, such as is sometimes noticed near the sides of swift-flowing streams of water. In such cases small pieces of paper may be dropped into the fan at the sides of the outlet, even when the fan is running at high speed. This counter current of air is again taken up and expelled, and continues in this motion to the loss of power that should otherwise be utilized. Again, should the outlet be too small a waste of power is met with in the resistance it offers to the free passage of the air, which is retained and churned in the fan uselessly. To obviate all this difficulty we make the outlet larger than absolutely necessary and adopt the shutter, a door, or gate, of sheet iron, sliding up and down in a groove, over the discharge outlet. Experiment and practice have proven the highly useful results obtained from this contrivance. By moving it up or down we can vary the size of the outlet to suit the speed of the fan and size of the airways, and, after experimenting to determine the point at which the best results are obtained, it can be adjusted to remain in that position as long as desired. And in this connection it may be said that when the fan vibrates the shutter should be regulated till the vibration stops. This vibration, however, must not be confounded with the pounding, before noticed, caused by a too short spiral. The position of the shutter may need changing to suit the various conditions of the mine, and should be carefully watched by the boss until he can from experience tell where to place it to obtain the best results in any case. This addition to the fan is found in few, if any, of those used in Ohio. As showing the effect of a change in the size of the outlet by moving the shutter, experiments at the Earnock colliery, in Scotland, gave results as follows: With the area of discharge opening forty-nine square feet the fan, at twenty revolutions, gave 69,400 feet per minute; at thirty-one revolutions, gave 115,500 feet per minute; at forty revolutions, 113,700 feet; at fifty-two revolutions, gave 187,300 feet per minute. With the area of discharge opening forty-one and a half square feet the fan gave, at twenty revolutions, 76,000 feet per minute; at thirty-one revolutions, 127,900 feet per minute; at forty revolutions, 160,900 feet per minute; at fifty revolutions, 198,500 feet per minute. With the area of discharge opening thirty-one square feet the fan gave, at twenty revolutions, 69,700 feet per minute; at thirty revolutions, 112,800 feet per minute; at forty revolutions, 135,800 feet per minute; at fifty revolutions, 175,600 feet per minute. Showing that the largest volume of air was got when the area of the outlet was forty-one and a half square feet. A 16 foot Guibal fan in the county of Durham, England, running at a regular speed of sixty revolutions per minute, showed variations in volume, with the shutter in different positions, as follows: Shutter raised one foot and three inches, the volume was 18,000 feet per minute; shutter raised three feet and six inches, the volume was 23,000 feet per minute; shutter raised one foot and nine inches, the volume was 39,000 feet per minute. In the first of these instances the fan was run at different speeds, and in the last at the same speed all the time, yet both results show the benefit of the shutter, and prove that it is possible by its use to find and retain the best size of outlet, and that the fans in our own mines can be regulated by it to conform to the conditions of any mine using them, and that in it we have the means by which the general form of fan considered above can be made to accommodate itself to the different requirements of different mines.

We next come to consider the expanding chimney. The theory of its action is that it affords an opportunity for the expelled air to expand, after leaving the fan, until its velocity is lost when it comes in contact with the denser air of the surface, at the top of the chimney, and it passes out without resistance from it. In fans without chimneys the rarified and lighter air of the mine is thrown with great velocity against the denser and heavier air of the surface, meeting with a resistance from it very detrimental to the perfect operation of the fan. The chimney should be of the same area at the bottom as the discharge outlet of the fan, and may be made of wood, with the joints well battened and made air-tight. It should commence expanding and increasing in area at once from this point to the top. The rate of expansion, and the height, should conform to circumstances, and no general rule governs the matter. It is unnecessary to have it too high, and yet it should be high enough to allow the air to part with its velocity in its passage upward and pass out without resistance from the surrounding atmosphere.

That the chimney is of service in aiding the fan may be demonstrated by boring holes in its side, when it will be found that if a lighted lamp be placed at the holes, the flame will be drawn into the chimney through the holes. M. Murgue, as before noticed, has shown it to be of great advantage, and has also shown that even a chimney of constant area is of service, while M. Guibal himself claims an increase of 26 per cent. useful effect from its adoption. A chimney to a fan I have never seen west of the Alleghenies, yet I venture the assertion that if placed upon almost any upcast fan now in use, it would be found to largely increase the volume of air delivered, even where radical defects exist in the construction of the fan.

We have now considered the fan, as compared with the furnace, and have noticed some demerits of faulty construction. We have also considered the conditions necessary for good work, and the best form of fan for service in our western mines. We find from the inquiry that the two most important factors in the successful working of the fan, viz., the shutter and the chimney, have been entirely neglected by our fan-makers as well as by our mine-managers. It is true that neither of these are needed in a fan constantly used as a downcast, but there can be no doubt that the adoption of one or both would very materially benefit the working, and increase the volume of any upcast-fan now in use. The chimney can be built at little cost, and, where the fan construction will not admit of the addition of the shutter proper, its functions can be approximately secured by putting on and taking off boards over the discharge, measuring the air at each change until the best size is found and kept. Of the many errors of construction, this of the size of the discharge is the most pernicious, and the oftenest met with. Other deficiencies can be overcome, or reduced, through the medium of these two appliances, and their absence from any fans now in use, serves to demonstrate, in a striking manner, the lack of information existing among fan-makers, who follow generally the rules governing the construction of a blacksmith fan, or a hall ventilator, none of which are in any way applicable to mine ventilators. The mine-managers of the West are rapidly taking advantage of, and adopting the most improved mine machinery, and it is to be hoped that this spirit of enterprise may soon reach out in the hitherto neglected direction of a perfect fan, and that those of proper construction may take the place of the many abortions now so common.

Resolutions on the Death of John Stambaugh.

WHEREAS, It has pleased Almighty God to remove from our roll by death, John Stambaugh, it is but proper that a brief outline of his life should be given to the readers of the *Ohio Mining Journal*. He was elected an honorary member of the Institute, May 10th, 1883, at our summer meeting, held at Youngstown, O., on that date. Mr. Stumbaugh was born at Brier Hill, Ohio, May 7th, 1826. His boyhood was spent on his father's farm. When quite young he entered the office of Governor David Tod as a bookkeeper, where he remained only a few years, resigning to associate himself with Richard Wooley, and enter the coal business as miners and shippers of the celebrated Brier Hill coal, which he continued to follow to the day of his death. In 1858 or '59 he, with the late Governor Tod, built and operated the blast furnaces at Brier Hill, since when he has been actively engaged in the iron business. He was also largely interested in iron ore mines in the Lake Superior region, the Coke regions near Uniontown, and the coal mines at Port Royal, Pennsylvania, and many other enterprises, both at Youngstown and elsewhere, and left, as a result of his energy and shrewd business habits, a magnificent fortune. Mr. Stambaugh was of a retiring disposition and studiously avoided public notice, but was one of Youngstown's most public-spirited citizens. Generous to a fault, it can be truthfully said of him, no worthy person ever applied to him for aid that was turned away; and in all public enterprises his name was at the head of the list. Among his generous donations is the beautiful lot on which is erected the city hospital, and his aid to it during and after its erection: from the piazzas of which the beneficiaries of his generosity can overlook his last resting place.

Resolved, That in his death the Ohio Institute of Mining Engineers have lost a valuable member and friend, and that its members extend to his family their heartfelt sympathies in their bereavement.

R. M. HASELTINE,
ANDREW ROY,
THOMAS B. BANCROFT, } *Committee.*