M. Lommel fixed the brass rod in a certain position, and moved the ebonite plate up and down under it, taking figures at each position. He also used an ebonite plate with an aperture, allowing the brass rod to pass through it. He shows how the various figures are related to the original two. The cause of the Lichtenberg figures is to be found (he thinks) in a peculiar state of motion of the air about the conducting body, and this is simply imaged on the ebonite plate.

TURBINE WATER WHEELS.

BY S. W. ROBINSON.

A look at the numerous turbines on exhibition in Machinery Hall, and their elaborate catalogues, giving lists of the thousands which have been introduced in this country, gives evidence of a thriving and extensive business; and one can hardly realize that thirty years ago the turbine was scarcely recognized as a motor.

The first wheel of this kind was made in France by a Frenchman named Burdin, in 1827 or 1828, but the real merits of the wheel were not generally accepted till some five years after. Soon after this it began to receive the attention of American engineers; and the first of these wheels of importance was constructed by Uriah A. Boyden, in 1844, and introduced into the Appleton Company's cotton mills at Lowell, Mass. Tests of these wheels gave remarkable results, the maximum being 92, and the mean maximum 88, per cent of useful effect from the power of the water.

This extraordinary figure is supposed to be due to the engineer's extreme precaution in polishing the surfaces of the apparatus, using Russian iron guides and floats, and in giving such form to the flume as to impart to the water, as it approached the guides, such a spiral-like rotation as to cause it to enter the guides without resistance. The trials which gave the above percentages decided the great superiority of the turbine over the old breast wheel, and engineers at once saw that, for perfecting water motors, their attention must be turned into a new channel.

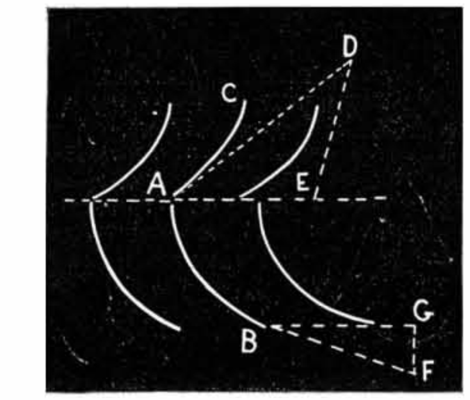
The breast wheel was at once summarily dismissed, and the turbine adopted for reasons unmistakably in its favor, some of which are the following: 1. Increase of percentage from five to fifteen. 2. Greater compactness. 3. Perfect freedom from back-water annoyance. 4. Perfect adaptation of given wheel to all heads. 5. More convenient speed of running. 6. Much less subject to fluctuations of speed. 7. Convenience of installment, and for shipment ready made. Advantages of breast wheel, none.

Some of these point are self-evident, but others, such as Nos. 1, 3, 4, and 6, may not be. To help this, and also for the reason that the correct theory of the turbine wheel is but poorly comprehended, as evinced by the forms given the parts in existing ones, the following descriptive exposition of the main theory is given with the hope that practical builders may thereby receive a benefit.

First of all, water wheels must receive power from the water by reducing its velocity, and water engines by action of its pressure. These points are believed to be sufficiently evident from observation. It is therefore obvious that, for a maximum of effect, the water should have the greatest possible velocity due to head in approaching the wheel; and in leaving, the motion should be entirely destroyed. To illustrate, suppose a flat disk be placed square against an isolated jet of water. If stationary, the water will be thrown in all directions without much change in velocity, and no power is developed because standing still. If it moves with the water the stream is not disturbed, and also no power developed. At half the water velocity, the vane receives its greatest power, but the water is projected laterally, and for this reason the motion of water is not destroyed, and the maximum of effect is known by hydraulic engineers to be only half the power stored in the moving jet. But this is what may be styled a fair example of percussion, and hence builders of wheels who operate on this principle must expect low returns.

Next, suppose the vane be in the form of a hollow half cylinder, and placed so that the jet strikes it tangentially at one side. While stationary, the water is sent around the smooth surface, and escapes, with velocity unchanged, in a direction differing by 180°: and of course we have no power. Giving the vane the velocity of the jet, we get no power again, but with half the velocity of the stream it receives the water with a relative velocity, one half its absolute, and passes it to issue at 180° unchanged, at which the absolute velocity of the water is zero. Now multiplying the motion of vane by the pressure against it, the result is found to be equal to the whole power of the water. In this example we see that the water is delivered upon the float without shock or percussion, and leaves it without velocity, which principle has long been known in theory as the necessary condition for high percentages. As this has regard to the power of the jet only, the latter should, of course, be made the maximum, by giving the water the highest possible velocity of projection. Of the forms of orifice of projection, the one known, from experiment, to give the greatest velocity is that formed in a thin wall, whose coefficient, or realizable percentage of the theoretic velocity, is about 97. Rapidly converging adjutages give very nearly this, say upwards of 92, while prismatic adjutages give only 82 per cent. Hence a turbine, whose chutes have parallel sides, can only return a percentage of 82, provided the wheel otherwise be absolutely perfect. It is therefore evident that the form of chute is of no whit less importance than the wheel.

Again, in turbines there should be a certain adaptation of chutes and floats to each other, and certain forms of wheel passages and exits. The forms most consistent with theory are best explained by aid of the accompanying diagram, which may be regarded as a side view of a Jonval turbine. Let A B represent a float of the wheel, and A C a guide. Let D A represent the direction and velocity of the affluent water, and B F the same for the issuing water. Take A E or B G for the velocity of wheel, which must be equal, from the nature of the case. The point, D, should be found by making D E equal to A E, and the direction of D E the same as the first elements of the floats. Then we have D E = A E = B G.



Now if a particle of water moves from D to A, while a point on the wheel moves from E to A, the direction and velocity of the water, relatively to the wheel, will be D E, and hence will enter tangentially upon the float with entire freedom from shock. Compared with the cylindrical vane above, the water will move along the curved float, A B, without change of velocity, and issue with a velocity, B F, equal to D E. But as D E = B G, then B G = B F, and the absolute velocity of the water will only be G F. If the water could be made to issue tangentially, G F would be zero, as required for a percentage of 100. Though in practice G F must have a magnitude, it should be reduced to the minimum. The water has also been regarded as having uniform velocity from A to B. That this be possible, the transverse sections through the inter-float passages should be the same at all points. Hence, that the exits be thin, requires them to be long from crown to crown. And again, in order to deliver the water on wheel in direction, D A, the last elements of the guides should have the direction, D A; otherwise the form should be favorable for high velocity of projection.

Now this diagram may be greatly varied, and still these principles hold equally well. It is only necessary that D E = A E = B G = B F; last element of guide have direction D A; first element of float have direction D E; and inter-float passages be uniformly large from beginning to exit. The velocity of wheel will be to that of the water as A E is to A D. When the first elements of float, for instance, are perpendicular to A E, the guide direction, A D, should be 45°. For float direction, A D, 60° to the right, guide direction will be 60° to the left, and A D E will be an equilateral triangle. Indeed A D E is always an isoceles triangle.

In designing a wheel it is very important that there be no interference to free passage of water in the curbing or penstock, or in the vent from wheel; and hence these should be large and unobstructed.—*Polytechnic Review.*

THE BLACK KNOT.

There are many things in Nature seemingly so insignificant that we consider them unworthy of our notice; yet they have the power of doing us great benefit or harm according to their habit. The mold, upon bread, cheese, and on most other neglected vegetable matter, is well known to be a plant growth of a low order. It is a fungus, and of the same nature as our common mushrooms. The potato disease, which is causing so much anxiety in England and on the continent of Europe, is also the result of a fungous growth. These plants are now receiving considerable study from botanists on account of both their practical and their scientific interest.

In this country, and peculiar to it, the black knot, as it is called, on plum and cherry trees has recently been proven to be another fungus. Dr. W. S. Farlow, of Harvard University, has presented, in the *Bulletin of the Bussey Institution*, a most important paper as the result of his researches on this subject. The black, warty excrescences on plum trees and on all kinds of wild and cultivated cherries have been noticed by every one from early time, and have long been the bane of fruit growers. For the most part, these have been attributed to the work of insects; and this has not been without considerable shadow of reason. Insects are not unfrequently found there, and in old knots insects or their remains are generally found. The curculio often pierces the knot in its young state, and deposits within it its eggs, which soon hatch out. The young live in the knot, and may be found there in the various stages of their development. Insects also of different species have been found within these knots.

But it is now conclusively demonstrated that the unsightly knots are not of insect origin. Though, till very recently, the subject has been almost entirely neglected by botanists, it now seems certain that they have determined its true character. The knots are not like galls, made by a known insect; and when young, they are most frequently entirely devoid of insects. Again, the fact that the insects are not all of one species, and the very same are also found on trees which are never afflicted with knot, would be quite conclusive against this assumption. On the other hand, the knot has never been found without the presence of the specific fungus (*sphæria morbosa*), which is now accepted as its origin; and this fungus is not known to exist except in connection with the knot. The mycelial threads, however, of the fungus are found in the slightly swollen stem long before any real semblance to a knot has appeared; but the growth of these may be traced till the knot has attained its full size, and the fungus has shown all its phases of life.

Dr. Farlow has considered the life history of the fungus, whether the disease is the same on plum and cherry trees, and the means of preventing its ravages.

The knots vary in size from a few lines to several inches in length, and average about two inches in circumference. They seldom entirely surround the branch, and often cause it to bend or twist into unsightly shapes. The vegetative portion first appears in the form of very minute threads (mycelium), twisted together and extending from the cambium—or inner—layer of the bark towards the outer portion of the stem. "The fungus first reaches the cambium either by the germination of spores on the surface of the branch, or by the mycelium proceeding from a neighboring knot." Hence the Professor concludes that the growing layer of tissue is where the fungus commences its work of destruction. During the growing stages of the knot—which continue to the flowering time of its victim—it is of a greenish color and solid or pulpy throughout. When it has attained its maturity, it turns black; and in the winter it often becomes cracked, broken, worm-eaten, and hollow. The outer shell contains the perithecia, which are small pits or sacs containing the sexual spores. These, always eight in number, are borne in *asci* or cells. These cells grow slowly during the winter, and the spores in them ripen from the middle of January to the end of February. Those ripening in February germinate in from three to five days, if sufficiently moist.

Microscopic investigation proves that the knots on plums of all sorts, and on cultivated, wild, and choke cherries, are identical: though, to the naked eye, they differ slightly in general appearance, owing probably to the more favorable circumstances for their growth in some species of the genus *prunus* than in others.

The remedy against this contagious disease is a very obvious one: simply to cut off and burn the knots and swollen branches when and wherever found. This should be done in autumn as soon as they become plainly seen by the falling of the leaves. It is not sufficient to cut them off, for some of the spores which do not ripen till late in the winter have been carefully observed to ripen after the branches were cut from the tree and not afterwards burnt. Professor Farlow recommends the complete destruction of choke cherry, bird cherry, and wild plum trees, since they furnish means for the rapid propagation of the knot, and are themselves of little value in comparison with the cultivated cherries and plums. "Concert of action is what is needed in this matter, and not only by attending to one's cultivated trees, but to the wild plums and cherries that frequent our fence rows and woodlands as well: as in very many instances the latter prove to be pest houses where the contagion is propagated and sent forth to carry desolation over many a thriving tree, dear to the eye of its owner." The wild plums are the most abundant in the Western States, and the wild and choke cherries in the Eastern. These, in their habitats therefore, require special attention.

This is a matter of vast importance to fruit growers; and to institute vigorous measures, against this destructive fungus, will be a great source of profit to fruit producers and merchants, as well as an equally great source of comfort and enjoyment to the consumer. S. H. T.

The American Reports on the Vienna Exposition.

We have received the four volumes of reports of the United States Commissioners to the Vienna Exhibition of 1873, which have just been published, under authority of Congress, at the Government Printing Office, at Washington, D. C. The work possesses a double interest: first, in that it is a tangible result of the expenditure of $200,000 of the people's money, and of the labors of certain paid scientific commissioners and eight practical artizans: second, in that it is a valuable record of the Vienna show, edited with much ability and discriminating judgment.

Professor Thurston devotes volume first to an introductory description of previous world's fairs, following which is a complete account of the organization of the Vienna Exposition. Copious extracts from the reports of the commissioners from other nations uponthe United States exhibit are given; and a report on forests and foresting, by J. A. Warder, M. D., and one on sheep and wool, by J. R. Dodge, close the volume. In volume second are collected all the reports on scientific and educational subjects. Volume third is mainly occupied by the editor's own report on machinery and manufactures, to which are added Mr. William Watson's paper on "Engineering and Architecture," that of Mr. Fairfield on "Sewing Machines," and that of Mr. Charles Davis on "Hydraulic Engineering." Volume fourth contains reports on buildings, wood and stone industries, metallurgy, and a copious general index, which greatly adds to the value of the work as a book of reference. There is a lavish profusion of maps and engravings, and the general appearance of the book is superior to the usual official productions of the government printer. We shall, as opportunity offers, lay before our readers such abstracts from the work as appear interesting. Meanwhile, and in advance of the public verdict, we can warmly commend Professor Thurston's labors. He has accomplished a task of great magnitude, with a thoroughness which will secure wide and favorable recognition, and he has given us probably the best set of reports ever based upon a world's fair.