forms of water engines. They still remain, as a class, unexcelled in economical efficiency, but they have found rivals in the smaller, quickly working, and far cheaper and more satisfactory turbines, and have been almost completely driven from the field.

The power of prime movers is measured by horse power. Watt found that the strongest London draft horses were capable of doing work equivalent to raising 33,000 pounds one foot high per minute, and he took this as the unit of power for the steam engine. The horse is not usually capable of doing so great a quantity of work. Rankine gave 26,000 foot pounds as the figure for a mean of several experiments, and it is probable that 25,000 foot pounds is a fair minute's average work for a good animal. It would require five or six men to do the work of a strong horse. Watt's estimate has become, by general consent among engineers, the standard of power measurement for all purposes.

The weight of water flowing per minute, over a weir or dam, being multiplied by the hight of available fall, gives a product in foot pounds per minute, which, divided by 33,000, gives the horse power of the stream. Of this power, a certain proportion is always lost through the inefficiency of the machinery of the prime mover which is intended to utilize it. The best overshot and high breast water wheels yield as a maximum but little over seventy-five horse power where the available power of the fall is one hundred. The best turbines have about the same efficiency as the vertical wheels when precisely proportioned to their work. In all wheels, a loss greater than twenty per cent is met with when running on "part gate." There is, therefore, room for improvement in water wheels to the extent of twenty per cent or more. These losses are to be lessened by more skillfully proportioning the wheels, and especially by some arrangement which will allow them to work efficiently with varying gate. The prime defects at present exist in the method of adjusting the wheel to do its work with different loads. Hardly less important is the problem of effectively connecting the governor to the wheel gate. Much has been done in these directions, but much remains to be done. Some wheels will do nearly as good work at part gate as at full gate, but usually this efficiency is attained by the sacrifice of simplicity and of maximum economy. A wheel which will invariably yield seventy-five per cent of the power of the fall under which it works, and do this under all loads, is yet to be brought into the market. The high tide of progress has culminated in the successful competition of the small, lively, and cheap turbine with the older forms of wheel, which are now nearly driven out of use. By far the most important work in cheapening the construction of turbine wheels and in making them efficient has been done by American mechanics.

The windmill is largely used on our western prairies and to a considerable extent elsewhere. The improvements lately made on this motor have been principally in the structure and arrangement of the vanes, making them self-regulating, and in so constructing the apparatus that it shall keep itself pointed toward the wind. Abroad, nothing seems to have been done, but our own inventors have accomplished some good work in this field, the extent and importance of which are not generally appreciated. We have but little information as to the efficiency of windmills. They are probably less effective than water wheels, and their improvement remains a promising task for ingenious mechanics.

The force derivable from electricity has long engaged the attention of most active minds, but we cannot yet chronicle any really well settled and important advance towards its utilization. Indeed we can hardly anticipate its employment to any considerable extent until new methods of generating the force itself are discovered. The available power to be obtained by the consumption of zinc, which is the metal consumed in the voltaic battery, is estimated, by various authorities, at from one half to one sixth that derivable from an equal weight of coal, and the great difference in price between zinc and coal, pound for pound, makes the difference in cost of power vastly in favor of coal. A quarter of a century or more ago, many attempts were made, some upon a large scale, to utilize electric force in the production of mechanical power, but with no success. Our countryman Page, who in 1850 obtained power from a small engine at a cost, as he stated, of about a cent per horse power per hour was the most successful; but even he finally failed, and no one has since been more successful. Attempts are still made and are almost daily brought to our notice; and occasionally a charlatan or a self-deceiver deludes credulous listeners, by the claim of wonderful results. We hope that we may find such a claim well founded, in some time to come, but we fear that it will be very far in the future, unless some fortunate man shall discover a method of evolving electricity, in place of heat, from the oxidation of coal. That done, the problem would be far less difficult of solution, and we should look hopefully for a splendid development of this field, which would have then become most promising.

## PROGRESS OF THE CENTENNIAL.

With the object of enlisting the coöperation and interest of the people of New York in the coming Centennial, a delegation from the Board of Finance of that enterprise recently met with the members of the Chamber of Commerce of this city. The Philadelphia committee deprecated any feeling of sectional rivalry and urged, with much earnestness, the view that the exhibition was a national affair, and that it deserved the hearty support of the whole country. The New York merchants replied in similar strain, cordial expressions of coöperation were exchanged, and a committee of seven was appointed to solicit aid from the people of the State. As regards progress, we find it stated that the Board of Finance has confined its operations principally to Pennsylvania, in which State $3,500,000 have been subscribed by citizens and corporations. California has promised her full quota, and efforts have been begun in order to raise funds in Delaware and Maryland. The work of construction is to be rapidly pushed during the coming spring. A temporary building covering from 35 to 40 acres is to be erected, and the permanent structure will be commenced at the same time. The former edifice is to cost from two to three million dollars, and the latter, half a million. The machinery, horticultural, and agricultural halls, are each to cost $500,000, and it is believed that the preparation of the ground, sewage, etc., will use up the remainder of the $10,000,000 required.

The prospects of foreign participation are very encouraging. At the assembling of the German Parliament, Prince Bismarck recommended the acceptance of the invitations and also urged the appointment of a plenipotentiary to reside in Philadelphia during the Exposition, and of a commissioner for each State of the empire. Belgium has promptly signified her intention to contribute, and the republic of Ecuador has made an appropriation for the purpose, and already has a resident commissioner in Philadelphia. Official notifications of intended participation have also been received, by the Government, from Mexico and Hayti. Professor W. P. Blake, special agent for the centennial at the late Vienna exhibition, says in his report that he has received assurances of friendly interest from the Emperor of Austria and other high officials. He has already obtained contributions for a permanent museum, consisting of Swedish iron ores, and a valuable collection of terra cotta work, samples of ozokerit, etc. China and Japan, it is considered, will be well represented, and the Turkish merchants are to erect a grand bazar, coffee houses, bath, and, in some convenient portion of the grounds, a complete Turkish village.

We hope capitalists, merchants, manufacturers, inventors, and every other class of our citizens will take an active interest in promoting the success of this great patriotic Centennial exhibition.

## EXPERT ENGINEERING.

We are constantly in receipt of inquiries as to what are the requisite qualifications for an engineer. This word as it is frequently employed is somewhat of a misnomer. An engineer, in the broadest signification of the term, is an expert in engineering, one who is practically acquainted with the construction and management of heat engines: who is thoroughly versed in the physical laws which relate to the formation and use of steam and other motive powers: who can design machinery, and adapt it to the various purposes for which it is intended. But in common parlance, every one who has control of an engine or boiler is known as an engineer. From this fact, much misunderstanding frequently results. The proprietor of a factory, for instance, sees no difference between the person who takes care of his engine and the consulting engineer who offers his services in expert cases, except, perhaps, that he looks upon the former as a practical man, and therefore one who is always certain to think and act correctly, while he considers the latter a theoretical engineer, whose opinions are entirely too visionary to be of any value. We think we have not overstated the comparison that is usually made between what are known as practical and theoretical men. But it may be worth while to look into the matter a little, and see whether the popular estimate is a just one. The purely practical man, as we understand it, is one who knows nothing but what he has acquired by actual practice; and things that he has not seen and handled, as it were, he will not believe. Now the engineer who is understood to be theoretical has ordinarily enjoyed quite as much practice as the other, but he has labored more understandingly, investigating the principles of the work in which he is engaged, and endeavoring by the application of these principles to effect changes and improvements. There is little doubt that the intellect of man is his most valuable possession, and that the cultivation of this faculty will give him greater rewards than he can hope to acquire by manual labor. It is true, however, that his theories, if unsupported by facts, are little better than idle dreams, so far as their value to the community is concerned. James Watt, in making his splendid inventions relating to the steam engine, carried theory and practice hand in hand. Starting with a rude model, he determined practically what it would do, and reasoned out what it ought to do if it were a perfect machine, and then turned his attention to making it fulfil the conditions called for by his theoretical investigation. Surely the result justified all his experiments and hypothesis.

Professor Rankine, lately deceased, and perhaps the most remarkable engineer that the world has ever known, united, in a most happy degree, the use of theory and practice. The result of his labors, cut short by an early death, can hardly be appreciated as yet; but in giving to the world the first accurate theory of the action of heat engines, he has enabled future experimenters and inventors to work with a clear knowledge of the nature of the problems which they wish to solve.

We hope we have succeeded in demonstrating to our readers that theory and practice are not naturally antagonistic, and that the professions of engineer and engine driver, both honorable ones, are quite distinct, the former comprising all that is contained in the latter, and embracing additional details.

If we have induced the owner of steam power to alter his opinion of the expert engineer, perhaps we may persuade him that he can occasionally employ the services of this expert with profit to himself. If every time that steam was raised in his boiler a large quantity continually escaped through some opening that was plainly visible, he would not hesitate a moment to have the leak repaired. We are able to state, from our own knowledge, that this state of affairs practically exists in many places where steam power is used, with the important exception that the leak is not visible to the ordinary observer. To find this leak is the task of the engineer, and surely the owner will be amply repaid if he succeeds, for a trifling amount, in having repairs made which will save him thousands of dollars yearly. The Royal Agricultural Society of England, at their yearly exhibitions, are accustomed to test the engines that are entered for competition. An investigation of the results obtained from year to year shows a most extraordinary improvement in the engines, as regards economy and workmanship, and there is little doubt that the effect of these tests has been most beneficial to the users of steam power. In this country, comparatively few reports of tests have been made public, and we are lamentably ignorant in regard to the performance of machinery made even by our best manufacturers. This is a matter in which every user of steam power is directly interested, and we hazard little in saying that all owners of steam engines would find it profitable to have tests made by reliable experts at least once a year. From examinations that we are continually making in the city, and by letters that we frequently receive from abroad, we are convinced that there are many steam engines which stand in need of professional assistance. The steam engine indicator has been likened to the stethoscope of the physician, but it should be remembered that either, in unskillful hands, will be productive of but little benefit. There are many cases, besides, in which other tests than those made with the indicator are called for; but so far as our experience goes, the skillful engineer is generally able to find the trouble and devise a remedy, when his services are called into requisition.. Those who are accustomed to read that portion of our paper devoted to questions and answers have doubtless noticed that we receive many letters in relation to the power that can be transmitted by a belt. It is a very common practice in letting power to calculate the amount furnished from the width and speed of the driving belt. But this is a very uncertain estimate, as in some cases the belt will transmit more and in others less than the rated power. If a few tests were made of the bulk of a pound of sugar, and the article were ever afterwards sold by guess work, the bulk furnished being based, by the seller's eye, on the amount previously determined by experiment, we venture to assert that neither dealer nor purchaser would be satisfied. And yet this is just the course pursued in circumstances where the amount of power can be as accurately determined as the quantity of sugar to be furnished for a pound. Cases have come to our knowledge in which the amount of power actually furnished varied as much as two hundred per cent from that given by calculation.

Some years ago, we heard of a bridge contract being let, in which it was stipulated that none of the material was to be strained, when subjected to the maximum load, to more than one sixth of its ultimate strength. When the structure was completed, a simple calculation showed that the maximum load brought a strain equal to one third of the ultimate resistance. The bridge commissioners performed a simple sum in arithmetic for the benefit of the constructor, worked somewhat in this manner: If a tun of iron costs D dollars, and it would require W pounds to give a factor of safety of six, and the price of the bridge is to be P dollars, if constructed according to specifications, what should its price be if it contains only half as much iron, so as to give a factor of three? Payment for the bridge was made according to the solution of this question, to the intense disgust of the contractor. A similar sum might be worked out with considerable profit to the purchasers of many steam engines and boilers, who find that their machines fall far short of the power at which they were rated by their makers.

This article has already extended beyond our proposed limits, and we have merely touched upon the benefits that users of steam power can obtain from reliable expert assistance.

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