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Contents:

(Illustrated articles are marked with an asterisk.)

THE WATER WHEEL TESTS AT LOWELL.

The opinions we have already expressed in regard to the tests of turbine water wheels, made at Lowell last summer, have strong confirmation from letters received by us from exhibitors and others, cognizant of the facts in the case.

The announcement of the tests contained a general invitation to those who wished to exhibit the working qualities of their wheels, and it gave the impression that everything would be complete, open, and fair, and that each wheel would stand or fall solely upon its merits.

We are informed that the tests were not properly made. The apparatus for measuring the water delivered to the wheels was perfect at first, being constructed after the specific published directions of Mr. Francis; but the edges of the weir became much battered by the action of rubbish that passed over it, in consequence of draining the canal every night for repairs. This compelled the opening of the wheel-gates and also the flood-gates to allow *debris* to escape. The foundation of the bulkhead also became unsettled by the large volume of water passed through and under it, throwing the weir out of level.

We are further informed that the flume, or bulkhead, was not so constructed that the exact available head of water upon the wheels could be determined. No two wheels could be put in alike or occupy the same relative positions. Thus it was impossible to approximate similarity of conditions in the different tests. As one correspondent says, the experiments were, in this respect, mere "cut and try." In one case the water had to turn three right angles, resulting in a loss of two per cent of the head as ascertained by measurement, and of course also giving rise to commotion in the water which injured the effectiveness of the wheel to a greater or less extent.

Fault is also found with the friction brake used in the test, as being unreliable and treacherous. It is said that this brake did not allow the wheels to run steadily; that at times it would allow a wheel to move with a uniform motion, and then would suddenly stop motion altogether. It is stated that at best it would not hold the weight steady one second.

The following terms were prescribed for the test: The wheels should be the ordinary manufacture, and should give about forty-horse power under 14 feet, the cost of test not to exceed a stipulated sum.

Notwithstanding, wheels of various degrees of finish were brought to the test. There was no uniformity in size, some giving not more than eighteen-horse power. The expense, it is said, also exceeded the stipulated sum six-fold.

The apparatus was located on a canal already too small to supply the necessary water to the mills located on it. For weeks at a time there could not a drop of water be had for testing in the day time save a few minutes at noon; and the tests made after September were only such as could be snatched from time to time, at short intervals.

It seems that this incompleteness of the arrangements prevented the satisfactory performance of even preparatory experiments; and it is understood that only one public test was made.

It will thus be seen that the public has lost nothing by the suppression of any report of these tests.

IT is said that an English firm has recently fitted up the engines of a small steamer on Warsop's aero-steam principle ith highly satisfactory results.

THE WAGES OF MACHINERY.

"There are in the United States about thirteen millions of laboring *men, women,* and *children.* There are also a very large number of laboring *machines.* It is estimated that there is steam machinery in the United States equal to two million horse power, or more than fourteen millions of full-grown men. A large portion of this machinery works day and night. It is never sick, never idle, never goes on sprees, never strikes. It always works, when required, up to its full capacity, and never tires. It is not unreasonable to estimate the work of the machinery as equal to that of twenty-eight millions of full-grown industrious men. It is evident, therefore, that only one third of the work of the country is done by its *laboring men,* and two thirds are done by its *laboring machinery.* Is it not clear that the wages of the laboring machinery constitute a larger portion of the cost of manufactured goods than the wages of the laboring men? Would not a reduction of the wages of the laboring machinery go further to reduce the price of goods and facilitate competition than a reduction of the wages of the laboring men. Of course it would."

The above from *The Free Trader* is a fair sample of the ingenuity brought to the support of the doctrine of free trade; an ingenuity which expends itself in concocting sophistical arguments to mystify and delude those who have not the time, or the facts wherewith to test their accuracy. We would only add a single word to the above quotation, and that at the very end of it, "*Of course it would not,*" is the way we would read it, and for the following reasons:

First, it does not follow that because machinery does the largest portion of the labor performed, that it does it at a greater cost than that of the aggregate manual labor of the country. There is no doubt that it does it at much less cost. It is not clear that the wages of laboring machinery constitute a larger portion of the cost of manufactured goods than the wages of laboring men.

In 1860, the capital employed in the United States, in manufacturing, was $1,009,855,715. The wages paid for manual labor amounted the same year to $378,878,966. Twenty per cent of the capital invested will, on the average, pay the entire current expenses of establishments driven by steam power, including the interest on the capital at seven per cent, repairs and depreciation, and exclusive of cost of the material worked and the manual labor employed.

We have purposely made a large average for steam-power manufactories. Where water power is employed the cost of running is much less, owing to the reduction in the fuel account. An average fully large enough for all kinds of power would be 15 per cent. Fifteen per cent of the total manufacturing capital above given would be $151,488,357, for the wages of machinery in 1860, as compared with $378,878,966—the wages of manual labor employed in the manufacturing business.

But the value of manufactured products was, the same year, $1,885,861,676. The wages of machinery was only a trifle over eight per cent of the value of the goods and wares produced. So that if, instead of demanding such enormous wages as the *Free Trader* would have us believe, the machines would be generous to the consumer, and work for nothing and repair themselves, the reduction in the price of goods thus secured would be only eight per cent.

But as the machines will not work for nothing and repair themselves, the free traders have determined on reducing their wages by a removal of duties on iron and coal. The cost of iron in the construction of machines made wholly of that material will not average over ten per cent of their selling price. So, provided that iron were to be obtained without any cost, machines could be thereby cheapened only one tenth, and as the interest on the first cost of machines, and the depreciation which eventually necessitates the purchase of new machinery are items in the entire wages of machinery, which perhaps may be estimated at ten per cent of capital invested, we find that the reduction in the cost of manufactured goods consequent upon the reduction of the wages of machinery caused by getting the iron for nothing at all, would be only one tenth of one half of eight per cent of the entire value of manufactured products, or two fifths of one per cent.

We have already said enough on the subject of the tariff on coal, about which there has been such a hubbub. There is no reason to believe that its removal would affect the price of coal in any appreciable degree.

This attempt to show that machinery is overpaid and that the working man suffers thereby, deserves to be ranked with the attempt to prove that the tariff on salt—18 cents per 100 lbs.—must inevitably render the luxury of salt codfish inaccessible to the poor.

WASTE OF LABOR IN BUILDING.

Of all the painful sights we are called upon to witness in this day of steam engines, and labor-saving appliances, none strikes us as being so absurd and unnecessary as the waste of human toil in building as it is generally conducted. Hodmen crawling up long ladders with small burdens of bricks and mortar, carrying at each trip some sixty or seventy pounds of building material, with thirty or forty pounds of hod, and one hundred and sixty or more of flesh and blood—not to mention beer—seems something so foreign to this age of machinery that we should scarcely feel it more incongruous to see the stocks and pillories restored to our market-places.

If a huge beam or girder is to be raised, we see the crane, tackle, and steam engine employed, but the ordinary carrying is done by human legs. These legs, although they can do climbing passably, are certainly inferior in this respect to other legs designed by nature to make climbing a specialty. A ladder is a very serviceable appliance in its way; we however, believe it to be as hard a road to travel as ever the genius of man devised. The hod belongs to an ancient and honorable family of implements, but it does not seem the most agreeable companion in the world to clasp in affection ate embrace or place one's cheek fondly against.

Therefore we say down with the hod; let it take its place with the host of implements, on the tomb of which modern progress has written the epitaph—"PLAYED OUT."

Let us suppose the two side pieces of a ladder to be replaced by iron rails and the rounds by ties, and let us suppose some genius to conceive the happy idea of causing a locomotive to crawl tediously up this heavy grade, drawing after it a load of one third its own weight. What gibings, what laughter, what derision would such a scheme excite among mechanics! Yet we are importing annually large numbers of locomotives to do the same thing; only these locomotives run on the ties instead of the rails.

They do these things better in France. Either derricks are employed, or the brick and mortar carriers are used as stationary engines, rather than as locomotives. In passing a building in process of erection in Paris, one may often see a number of men stationed one above the other along a ladder, each of whom passes his load to the next above him, until the load reaches its destination. In this way a continuous procession of materials is kept up, and a large quantity may be elevated in a short time.

This is an improvement on the climbing process, but there must even in this way be an enormous waste of power. And this waste is not only useless, but so easily avoided that the continuance of the employment of human power to perform such rude work, is a disgrace to modern civilization. It can be demonstrated that a small one-horse power engine, with suitable tackle, and the employment of a single man to attend it, will do the work of six men at elevating bricks and mortar, at a cost of less than the wages of two men.

No mechanic who reads this will fail to see many ways in which this application of steam power could be advantageously made. The ladder might be replaced by a railway up and along which a car-load of bricks or mortar might be made to roll, which track might be joined to and made continuous with a horizontal track, by means of an easy curve at the summit, the whole being adjustable to suit the progressive hights of the wall as they advance towards completion. It would require little genius to adjust the detail, and the cost of building would be greatly lessened by dispensing with the hod carriers.

FRENCH EXPERIMENTS WITH LIQUID FUEL.

For more than ten years M. H. St. Clair Deville has been experimenting with mineral oils as fuel. *Comptes Rendus* and *Le Journal de l'Eclairage au Gaz,* have lately published some interesting facts in regard to these experiments, a *resume* of which is our present purpose.

The oils employed have been obtained from various natural sources, and the experiments have also included the heavy oil from the Parisian Gas Company's works.

The experiments have determined the following points: In twelve kinds of crude oils analyzed, there was found to be from 82 to 87·1 per cent of carbon, 7·6 to 14·8 per cent of hydrogen, and 0·9 to 10·4 per cent of oxygen.

The heavy oil of the Parisian Gas Company has a specific gravity at 32° Fah. of 1·044, and at 88° Fah. 1·007. It is of a dark brown color, and contains 82 per cent of carbon, 7·6 per cent of hydrogen, and 10·4 per cent of oxygen, nitrogen, and sulphur. Heated to 424° Fah., only 12·5 per cent volatilizes. It remains fluid at 12° Fah. A tun of it contains about 220 gallons, and its cost is about fifty francs per tun, or in round numbers ten dollars in gold, our currency.

The amount of carbon added to the hydrogen contained in this fuel, must make it a very powerful heat generating combustible. It has nearly the lowest expansibility of all the oils, its coefficient of expansion being 0·000743, and the lowest coefficient being 0·000652.

The most important experiments with the heavy oil were made with a locomotive of the Strasbourg Railway Company. This locomotive has uncoupled wheels and outside cylinders. Its weight is twenty tuns, and that of the tender is fifteen tuns. It has a heating surface of 72 square yards.

The oil was supplied to the furnace from a tank, being fed by its own gravity. An additional supply was carried on the the tender, wherewith to renew the supply in the tank as required.

The fire was kindled by lighting some shavings and sticks on the floor of the fireplace and at the same time admitting a small quantity of oil. A jet of steam was sent into the smoke pipe from the blow-off pipe of another engine to increase the draft. It took an hour and a quarter to get up steam, during which time 11 gallons of oil were consumed. It was shown, however, that by consuming 12½ gallons of oil, steam could be got up in two and one half hours, without assistance from another engine, but with the inconvenience of a large amount of dense black smoke.

On the first experimental trip it was found that a speed of forty miles per hour was obtained with a consumption of about 14 lbs. of oil per mile.

In a second experiment a train of 70 tuns was drawn at a speed of forty miles per hour, with a consumption of about 17 lbs. of oil per mile.

Subsequent experiments gave results not differing essentially from those mentioned.

The grate consists of 20 bars of iron cast in one piece, with channels for the oil to run down, and it is set perpendicularly before the furnace which is lined with fire brick. A separate cock supplies oil to each grate bar.

It is thus seen that with the heavy oil, steam can be got up in about the same time as with coal; the combustion of the oil is not specially difficult to control; and that the consumption of oil, as compared with that of coal, is only about one half by weight.

It is stated that the fire brick used to line the furnace suffered severely from the intense heat, but the effect upon the tubes, c., of the engine do not seem to have been yet noted.

These experiments do not give much encouragement that liquid fuel will ever be adopted except in special cases. The price of such fuel could not be kept at its present figure were it in general demand for this purpose, and therefore its use would not probably result in any economy over that of the best coal.

THE ECONOMY OF STEAM ENGINES.

Many persons, using steam engines, fail to appreciate the value of inventions designed to produce economy of fuel. It is true that sanguine inventors and unscrupulous agents of stock companies often promise savings that cannot be realized in practice, but no one should condemn, wholesale, all devices of this character, because from lack of judgment he has been once deceived. Neither should he reject offered assistance because the promised savings are ridiculously large. All matters of this character should be decided on their merits. Some may be valuable though overrated.

The coal bills of a steam engine foot up rapidly, and a very small percentage of saving will pay for a great many improvements. It is easy to show that it is true economy to sell an old steam engine for scrap iron and purchase an improved engine at full market rates rather than pay for the extra coal required by the former. For instance, there are few engines working of the old style, regulating by the throttle valve, that furnish an indicated horse power for four and one half pounds of coal per hour. This is equivalent to say five pounds per hour for each net or effective horse power. An engine developing eighty net horse power would then require $(80\times5\times10=)$ 4,000 pounds of coal per day, or say 4,200 including banked fires at night. This for a year, or 300 working days, would equal $(4{,}200\times300\div2{,}000=)$ 630 tuns per year, which would cost, in many localities, upwards of four thousand dollars. Now, a new engine, with cut off adjusted automatically by the governor, of a size capable of furnishing economically eighty net horse power, costs from $4,000 to $4,500. So it is safe to say that engines constructed with no regard for economy, require yearly, for fuel alone, an expenditure of money equal to the first cost of a new engine. This would be true, also, in many places where fuel is cheap, if the original cost of the new engine were reduced by the sale of the old one, even for scrap iron.

From the above, then, it is evident that if the new engine saves only ten per cent of the fuel, this saving is continually paying ten per cent interest on the cost of the engine, while the work is being done the same as before. This is as good as most investments; but when it is considered that any engine, with modern improvements, will save thirty and even forty per cent of the fuel, as compared with the results above mentioned, the rate of interest becomes correspondingly large, and the engine is paid for by the saving in fuel in three years or less, or in four to five years when fuel is much cheaper.

Similar considerations apply with equal force to steam boilers, and to many of the details of construction of both engines and boilers. Any device that saves fuel saves money; and if it do not introduce complicated parts liable to derangement, it should be encouraged.

The simple feed-water heater is a good example of this, and saves on the average ten per cent of the fuel.

LIEBIG ON FERMENTATION.

Liebig has finally broken through the silence with which he has borne the attacks upon his theory of fermentation on the part of many chemists during the last ten years, and has come out with one of those exhaustive and convincing replies that recall the best days of his great intellect.

The reticence he has observed has emboldened some of the younger chemists to disclose weak points in their attacks, while others have looked upon the dead lion as a harmless creature, and have incautiously come too near his claws. All this small game is scattered like chaff before the wind with trifling effort, and the whole power and force of his argument is leveled at the French Academician and renowned champion of the new school, Professor Pasteur, of Paris.

For ten years Pasteur has had it his own way, and the views published by him have been fast gaining in popularity until they appeared destined to be accepted by a majority of scientific men everywhere. Liebig's paper is therefore a perfect bombshell in the camp, and as soon as the smoke has cleared up, and the fragments have been collected, we shall probably have about as nice a fight as has been witnessed among chemists for many a day. In the meantime we propose to give an analysis of what Liebig says in defense of his old theory of fermentation. It is difficult to make an abstract of so learned a paper, but we shall endeavor to render the subject intelligible to our readers.

Pasteur announced, nine years ago, as the result of his experiments, that Liebig's explanation of the action of yeast on sugar was entirely without scientific foundation.

According to Liebig, "a fermentable body is one which, by itself, or simply dissolved in water, does not undergo any decomposition, but when in contact with a putrescent body, is resolved into new products, or enters into fermentation. As fermentation is produced by the communication of motion from the atoms—not the molecules—of the putrescent body, to the atoms of the fermentable one, the process requires time; and the same is true of putrefaction itself. And as the ferment can only act so long as its atoms are in motion, so its power of exciting fermentation must cease as soon as its own decomposition is complete, and not before. Hence a given weight of ferment can only cause the fermentation of a limited quantity of sugar, or of any other fermentable compound."

On the other hand the views of Pasteur on fermentation are as follows:

"The chemical process of fermentation is essentially a phenomenon of life; it begins and ends with it; an alcoholic fermentation without simultaneous organization, growth, and development, that is, without continuous life, is impossible."

He regards fermentation as a chemical process accompanied by a physiological one; the duration of life of the ferment limits the splitting up of the atoms of sugar. Liebig says that there is nothing new in this view of the process. It was fully understood and explained by him in his chemical letters twenty years ago, and then, as now, he did not care to adopt it.

The action of ferments on fermentable bodies, says Liebig, is analogous to that of heat on organic substances. Their decomposition at high temperature is always the result of a change in the position of their atoms. Acetic acid is converted by heat into carbonic acid and acetone, just as sugar is split up by yeast into carbonic acid and alcohol; the carbonic acid resulting from the decomposition of the acetic acid contains two thirds of the oxygen, and the acetone all of the hydrogen, in the same way as the carbonic acid of the fermentation of sugar includes two thirds of the oxygen, while the alcohol contains all of the hydrogen.

The formation and increase of the yeast plant is dependent upon the presence and absorption of nutritious matter that develops the living organism; but in the process of fermentation there is an action independent of, and outside of, any products that the living organism can assimilate. The vital operation and the chemical action are evidently two phenomena, that in their interpretation ought to be considered separately.

To the opinion of Pasteur that the decomposition of sugar in the process of fermentation rests upon the formation and growth of the cells of the yeast plant, is opposed the fact that yeast will produce fermentation in a pure solution of sugar; and as yeast consists in the main of a substance rich in nitrogen and sulphur, also containing considerable quantity of salts of phosphates, it is difficult to comprehend how, in the absence of both of these constituents in the sugar, the growth of the plant cells can be promoted; and it would be equally difficult to explain how the beer yeast exerts the same decomposing action upon numerous other bodies as upon sugar.

Liebig has carried on an extensive series of researches in order to determine the action of yeast upon a great variety of substances, and he also cites the labors of the best chemists of Europe to show that his views of the action of yeast and leaven to produce fermentation is founded upon scientific principles, while the explanation of Pasteur is wanting in every element of theory and fact. It is so popular, not to say fashionable, to refer every vital action back to the formation of cells, and the building up of protoplasm, and to intimately connect life and matter together so as to gradually support the doctrine of spontaneous generation, that the publication of Liebig's great paper must be looked upon as a timely protest against the tendencies of the age. And it may serve as an intimation to younger men of science, anxious for fame, that the old methods of research are sufficient to furnish us with satisfactory explanations of the phenomena of nature without the necessity of having recourse to the supernatural or to the materialistic doctrines of the so-called protoplastic school.

The first part of Liebig's paper, which is all that has appeared, is devoted to fermentation; the second portion is to be occupied with the question of the origin of muscular force, and will be looked forward to by physiologists with great interest.

We shall not fail to inform our readers of the progress of the controversy, if anything practical grows out of it. A passage at arms between such men as Liebig and Pasteur cannot fail to attract the attention of scientific men everywhere, and it is not a little singular that the great German chemist should be ranged on the side opposed to the materialistic views so commonly attributed to his countrymen.

POSITIVE PHILOSOPHY.

The able exposition of the positive philosophy made by Prof. Fiske in his lectures at Harvard will do much toward clearing up many popular errors. As we have taken occasion once or twice to speak of those lectures in terms of commendation it may not be amiss to briefly state some of the prominent features of this system, premising at the outset that whatever we can say within the limits of an article like this must, of necessity, be of the most fragmentary and incomplete character. Evidently a system, the exposition of which in a university course of lectures compels the lecturer himself to condense to the exclusion of much almost essential to the clearest conception of his subject, cannot be discussed in a newspaper editorial. We shall therefore make no attempt at argument or illustration, and confine ourselves to giving, if possible, a glimpse of the fundamental principles upon which the system rests.

The first of these is the doctrine of the relativity of all human knowledge; by which is meant that all the human mind can either perceive or conceive, are the relations which do or may exist between phenomena.

Second, this system recognizes a limit to human knowledge and thought, and fixes the limit between the observation of relations and the attempted study of the essential nature of things.

It says you may find out the *how* of existence by experience and observation, but from the nature of the case it is impossible for the human mind to determine the *why*. You may perceive and classify phenomena, but the ultimate underlying causes you can never know because the human mind is incapable of forming any conception of such causes. You may see and feel the effects of what is called matter by the manifestation through it of what is called force, but both matter and force are merely names for the unknown and the absolutely unknowable. That these categories of existence are unknowable cannot, of course, be inferred from any knowledge of matter and force, since these are unknown; but from the constitution of the human mind, which cannot conceive the ultimate causes which these categories, matter and force include.

Hence it concludes that human study and knowledge must lie wholly this side of matter and force; must concern itself wholly with relations, manifestations, or phenomena; while the *noumena*, the ultimate causes, must remain a sealed book.

Now as all phenomena may be made the subject of demonstration it follows logically that this test must be demanded by all thinkers of this school, for the establishment of all the *facts* of science, before any inferences are allowable. Before reasoning from an asserted phenomenon, it demands to *know* the existence of the phenomenon.

The positive philosophy maintains that whatever conflicts with our direct perception of relations cannot be admitted as true; as to conceive anything is to perceive clearly the relations it bears to other things, and the relations of its parts to each other. Thus no man can believe at one o'clock that at three o'clock it will be two hours earlier than at one o'clock; this conflicts with his direct perception of relations. Such a proposition is inconceivable, and therefore would be rejected as false by any sane mind.

But while the positive philosophy insists that fundamental facts shall be demonstrated (we use the term not in the mathematical sense) it does not exclude inferences from facts, or deny that there may be causes antecedent to all facts; it only denies the capacity of the mind to deal with such causes.

Finally, it makes a distinction between belief in the sense in which the term is most ordinarily employed, and *knowledge*, but upon this point we cannot do better than to quote from the third lecture of Prof. Fiske:

"A necessary truth is one of which the negation is inconceivable after all disturbing conditions have been elimnated.

"A belief of which the negation is inconceivable is necessarily true, within the limits of human intelligence.

"This test of inconceivability is the only ultimate test of truth which philosophy can accept as valid.

"By a singular freak of language, we use the word *belief* to designate both the least persistent and the most persistent coherence among our states of consciousness—to describe our state of mind with reference both to those propositions of the truth of which we are least certain and to those of the truth of which we are most certain. We apply it to states of mind which have nothing in common except that they cannot be justified by a chain of logical proofs. For example, you believe, perhaps, that all crows are black, but, being unable to furnish absolutely convincing demonstration of the proposition, you say that you believe it, not that you know it. You also believe in your own personal existence, of which, however, you can furnish no logical demonstration, simply because it is an ultimate fact in your consciousness which underlies and precedes all demonstration. So with the axioms of geometry. If asked what are our grounds for believing that two straight lines cannot inclose a space, we can only reply that the counter proposition is inconceivable; that we cannot frame the conception of two straight lines inclosing a space; that in any attempt to do so the conception of straight lines disappears, and is replaced by the conception of bent lines. We believe the axiom because we must believe it.

"It is only in this latter sense in which the word *belief* is employed in the canon of truth above stated, and when Mr. Spencer says that a given proposition is inconceivable he means that it is one of which the subject and predicate can by no amount of effort be united in consciousness. Thus that a cannon ball fired from England will reach America is a proposition which, though utterly incredible, is not at all inconceivable; but that a certain triangle is round is an inconceivable proposition, for the conceptions of roundness and triangularity will destroy each other sooner than be united in consciousness. And manifestly we can have no deeper warrant for the truth of a proposition than that the counter-proposition is one which the mind is incompetent to frame. Such a state of things implies that the entire intercourse of the mind with the environment is witness in favor of the proposition and against its negation."

The reader must not, however, be led to suppose that with the disciples of this any more than in any other system of philosophy perfect agreement exists. So long as human minds differ in character, so long there must be differences in opinion, but the fundamental doctrine of the relativity of human knowledge is the foundation of the system, and is now very widely accepted by the best thinkers.

A MILE A MINUTE.

C. P. L. writes from Minnesota, asking "Are railroad locomotives, with six and one half feet drivers, capable of exhausting fast enough to allow them to run at the rate of one mile in a minute?"

This question opens an interesting and somewhat disputed subject. Locomotives with drivers smaller than those men-