PRINCIPLES OF SHOP MANIPULATION FOR ENGINEERING APPRENTICES.*

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(*Continued from page* 74, vol 2.)

MOTIVE MACHINERY.

Water wheels, next to steam engines, are the most common motive agents. For centuries water wheels remained without much improvement or change, down to the period of turbine water wheels, when it was discovered that instead of being a very simple matter, the application of water power really involved some very intricate conditions, and this gave rise to many problems of scientific interest, that in the end produced the modern turbine wheels.

A modern turbine water wheel, of the best construction, operating under favorable conditions, gives a percentage of the power of the water that (taking into account the friction of the wheel itself) almost reaches the theoretical co-efficient due to gravity, and it may be assumed that there will in the future be but little improvement made in such water wheels except in the way of simplifying and cheapening their construction. In fact, there is no other class of machines that seems to have reached the same state of perfection as water wheels, nor any other class of machinery that is constructed with the same uniformity of design and arrangement in different countries and by different makers.

Every one remembers the classification of water wheels met with in the older school-books on natural philosophy, where we are informed that there are three kinds of wheels—as there were "three kinds of levers"—namely, overshot, undershot, and breast wheels, with a brief notice of Barker's mill, that ran apparently without any good reason for so doing.

Without finding fault with this plan of describing water power, further than to say that a little explanation of the principles by which power is derived from the water would have been more useful, I will venture upon a different classification of water-wheels, that is more in accord with modern practice, and without reference to the special mechanism of the different wheels, except when unavoidable.

Water-wheels can be divided into four general types:

1. Gravity wheels, acting directly from the weight of the water which is loaded upon one side of a wheel revolving in a vertical plane, the weight resting upon the wheel until the water has reached the lowest point where it is discharged.

2 Impact wheels, driven by the force of spouting water that expends its percussive force against the float tangentally to the course of rotation and at a right angle to the face of the floats or vanes.

3. Reaction wheels, that are "enclosed," as it is termed, and filled with water under pressure, this water being allowed to escape through tangental orifices, and the force being derived from the unbalanced pressure within the wheel or from the reaction due to the weight of the water that is thrown off from the periphery.

4. Pressure wheels, acting in every respect upon the principle of a rotary steam engine, except so far as differences arise from operating with a non-elastic instead of an elasting fluid, the pressure of the water resting continually against the floats or abutment, without chance to escape except by the rotation of the wheel

To this classification might be added combination wheels, acting partly by the gravity and partly by the percussive force of the water; or acting partly by impact and partly by reaction, or by impact and pressure, which are common conditions of operation in water wheels.

The water wheel or water power, as a mechanical subject, is apparently quite disconnected with shop manipulation, but serves as a good example for conveying general ideas of force and motion, and, on these grounds, will warrant a more extended notice than the seeming connection with the general subject would otherwise call for.

In the remarks upon steam engines it was explained that power is derived from heat, and that the water and the engine were both to be regarded as agents through which power was applied, and, further, that all power is a product of heat. There is, perhaps, no problem in the whole range of mechanics more interesting than to trace the application of this principle to water wheels: one that is not only interesting, but instructive, and may suggest to the mind of the apprentice a course of investigation that will apply to many other matters connected with power and mechanics.

The power derived from water by means of wheels is due to the gravity of the water in descending from a higher to a lower level; but the question arises, what has heat to do with this? if heat is the source of power, and power a product of heat, there must be a connection somewhere between heat and the descent of the water.

Water in descending from one level to another can give out no more power than was consumed in raising it to the higher level, and this power we will find to be heat.

Water is evaporated by the heat of the sun, expanded until it is lighter than the atmosphere, rises through the air, and by condensation falls in the form of rain over the earth's surface, then drains into the ocean through streams and rivers, to again resume its round by evaporation, giving out power in its descent that we turn to useful a counts by means of water wheels. Evaporation is continually going on; the rainfall is likewise quite constant, so that streams are maintained within a sufficient regularity to be available for operating machinery.

The analogy between steam power and water power is, therefore, quite complete. Water is, in both cases, the medium through which power is obtained; evaporation is also the leading principle in both cases, the main difference being that in the case of steam power there is used a force arising directly from the expansion of water by heat, and in water power a force which is an indirect result of expansion by heat.

Returning to the classification of water wheels, gravity or "overshot" wheels, as they are called, seem to be the most effective and capable of utilizing the whole effect due to the gravity of the water; but in practice this is not the case, and it is only under peculiar conditions that wheels of this class are preferable to turbine wheels, and in no case will they give out a greater per cent of power than turbine wheels of the best class. The reasons for this will be apparent by examining the conditions of their operation.

A gravity wheel must have a diameter equal to the fall of water, or, to use the technical name, the height of the head The speed at the periphery cannot well exceed 16 ft. per second without losing effect due to the descending weight of the water. This produces a very slow axial speed, and a train of multiplying gearing becomes necessary in order to reach the speed required in most operations where power is applied. This train of gearing, besides being liable to wear and accident, and costing usually a large amount as an investment, consumes a considerable share of the power by frictional resistance, especially when the gearing consists of tooth wheels.

Gravity wheels, from their large size and their necessarily exposed situation, are subject to be frozen up in cold climates, and, as the parts are liable to be first wet and then dry, or warm and cold by exposure to the air and the water alternately, the tendency to corrosion of iron, or decay if of wood, is much greater than in submerged wheels. Gravity wheels, to realise the fullest effect from the water, require a diameter so great that they must drag in the water at the lower or delivering side, and are especially affected by back water, to which all wheels are more or less liable, from the reflux of tides or by freshets. These are among the most notable of the disadvantages pertaining to gravity wheels—disadvantages which have with other reasons, such as the inconvenience of manufacturing them, first cost, and so on, driven such wheels out of use by the force of circumstances rather than by actual tests or theoretical deductions.

Impact wheels, or those driven by the percussive force of water, including the class termed turbines, are now generally used for heads of all heights.

The theory of their action may be explained in the following propositions:

The spouting force of water is theoretically equal to its gravity.

The percussive force of water can only be utilised to its full extent if its motion is altogether arrested by the floats of the wheel.

The force of the water is greatest by its striking against planes at right angles to its course.

Any force represented by the water rebounding from the

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