THE INFLUENCE OF MOTIVE POWER ON THE DESIGN OF COTTON MILLS

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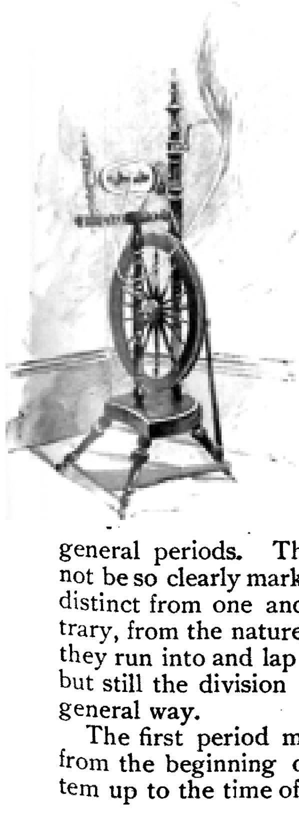

IN a paper read recently before the New England Cotton Manufacturers' Association, the writer undertook to deal briefly with the subject of modification in mill design resulting from changes in motive power. For this purpose the history of mill designing was considered as divisible into three general periods. These divisions may not be so clearly marked as to stand out distinct from one another; on the contrary, from the nature of circumstances, they run into and lap over one another; but still the division may be made in a general way.

The first period may cover the time from the beginning of the factory system up to the time of the general introduction of the modern automatic cut-off steam engine, which date may be placed about 1860. The second period may be taken as extending from the date just given to about 1893, when electric transmission began to be seriously considered in the driving of textile mills.

In the first period water power in its various stages of application was the ruling factor in motive power for textile mills. In the second period the steam engine disputed the sway of the water-wheel and succeeded in taking the primary rank. We are just upon the threshold of the third period, and a large part of what may be said must be regarded in the light of prophecy and not history.

In the early days of the factory system the water power was in a large degree the controlling factor. The mill was located with reference to the water power, and the particular development of the power in hand controlled in a very large measure the design of the mill structure.

It has always been considered of prime importance in designing transmission of power, that the drive should be as direct and short as possible. In the days of the water-wheel, when the breast and over-shot pattern of wooden wheels was in vogue, it seemed a necessity to so place the wheel with reference to the mill that short lines of shafting could be used. It was, therefore, the common practice to place these large wooden wheels at the centre of the mill, even though the building was a very small one, and then, by vertical shaft and gear connections, and a little later by a belt connection, to transmit this power from the wheel, located at the centre and in the lower part of the building, to the upper stories.

The topography of the site, together with the desire to secure economical power transmission from wheel shafts of low velocity, led the mill engineer to design buildings of considerable height and not covering a great deal of ground surface.

It is exceedingly rare to find a water-power development where the fall is of any considerable height, that affords a location for a mill, with a suitable and economical development of the power, that is so nearly level as to avoid one or more basements. It was frequently the case that two and even three full stories were built below the grade of the yard in the front of the mill, necessitating the lighting of this floor space from one side only.

The introduction of the modern turbine wheel, together with the demand for larger plants, marked a step in advance in mill design. It was found possible to place the wheels in such a position as would best suit the peculiar development of that power, and then to transmit the power through gears and shafting to some central point of distribution in the mill.

This gave an opportunity for a little freer development of mill design, in that more attention could be given to the exact requirements of the machinery and the organisation of the mill, and less attention to the particular relation of the power plant to the machinery.

Quite a number of mills are now in existence, or were within a few years, where the change had been made from the old-fashioned breast wheel to the modern turbine wheel; but the design of the buildings gave clear evidence of the limitations that were imposed by the type of water-wheel in use when the mill was actually constructed.

With the advent of the automatic cut-off steam engine with which the name of Corliss is indissolubly connected, the field was opened for a still further modification of mill design. It was no longer necessary to select a site by the river bank where the topography was more characteristic for its beauty than for its utility; but a spot could be chosen where a mill could be built much more economically, and where the requisites of light and ventilation could be met in a much more satisfactory manner. The topography of the site selected, without regard to motive power, may determine in a large measure the design of the building, and inasmuch as the change from water power to steam power allowed a freedom of choice in the matter of site, the simple change from water power to steam exerted great influence in the modification of mill design.

In the early practice of transmission of power from steam engines, when slower speed of shafting was in practice, it was thought necessary to place the engine near the centre of the building so that the transmission of power might be attended with the least possible loss; but as higher speed of shafting became common, and more perfect construction in the bearings and couplings became possible, less objection was found to long lines of shafting, and in order to secure less interference with the machinery in the mill the practice finally prevailed of placing the engine near one end of the mill, and transmitting the power from the engine to the main shafts by belts or ropes located in a tower.

It may be stated at this point that the improvement in water-wheels, and the adoption of horizontal wheels has rendered possible, in the case of water power mills, a proportion at least of that freedom in design which is more characteristic of the steam power mill.

The horizontal wheel with the draught tube enables the mill engineer in many cases to place the wheels where the best results can be obtained, and, at the same time, with slight loss in transmission of power, place the building on a much more desirable site for the mill than was possible where the old type of wheels was used.

It is, therefore, evident that the first two periods referred to in this article may not be distinguished absolutely as the water power period and the steam engine period, for the improvement in water-wheel design has furnished opportunity for a greater freedom in mill designing, in some cases approaching that of a steam power mill.

It still remained true, however, in the second period, if the desire was to use water power, that the mill must be located in the immediate vicinity of the water power development. If steam was to be the motive power, it was desirable to locate the mill building at a point where the fuel could be delivered at an economical cost.

The introduction of the electric generator and motor, at first regarded as the toy of the theorist, and a little later as a luxury to be enjoyed by those who had money to throw away, was the sure prophecy of a complete revolution in the design of textile mills.

At last it seemed possible to select a site that should be most convenient for the essential requirements in manufacturing, viz., the securing of labour, raw material, and transportation of the finished product at a minimum of cost, and to erect a building that should be exactly adapted to contain the required machinery, arranged in the best possible manner to fulfill its functions.

The possibility was seen and recognised long before the actual realisation was possible, for while it was theoretically possible to transform the mechanical energy of a water power or steam engine into electric power, and then conduct this power through copper wire to a motor located at the point of distribution of power, the cost of such apparatus, together with the heavy loss in transmission, was an effectual barrier to its adoption in any large degree.

Fortunately, the study of electrical transmission and the perfection of the apparatus was entered upon and pursued with such perseverance and success that we have already reached the point where it is not simply theoretically possible, but practically advantageous in many cases to locate the mill at the best possible point as concerns the design of the building and the organisation of the machinery, and utilise the power at any considerable distance from the mill.

It would seem, therefore, that under certain conditions the mill designer may be free from the limitations of the location of motive power in the immediate study of the design of the building and location of machinery.

It has already been stated that in dealing with this third period we must necessarily treat, in a large measure, of possibilities and not of actual experience.

It is, perhaps, impossible for any one to prophesy the rate of development along the lines indicated. It can hardly be claimed with justice that at the present time the electric transmission of power has reached such a state of development that it is applicable in all cases. It is, undoubtedly, true to-day that if a site could be selected and the source of motive power, either the water-wheel or the engine, so arranged that the power can be transmitted from the wheel shaft or the engine shaft, as the case may be, directly to the main shafts in the various departments of the mill, no saving, either in the fisrt cost of installation or the economy in running, would be experienced by substituting electrical transmission for mechanical transmission.

While this is true so far as a textile mill is concerned, where the load is practically constant throughout the sixty hours of the week, it would not hold in the case of manufacturing plants of other types where the load is not constant, and where different departments are likely to be run with varying loads and at different times. Under such conditions the time for the adoption of electrical transmission has already come.

There may also be cases where existing plants are so scattered, covering such an area, that no central power plant can furnish the power with mechanical transmission, with any good degree of economy, so that electric transmission is practically applicable.

In view, however, of the remarkable advance that has been made in a very few years, it is not difficult to imagine that before many years have elapsed it will be perfectly practicable and a positive advantage, even though the site may allow placing the motive power immediately within the building, that the power shall be transmitted to the various parts of the building by electric transmission, thereby modifying, in a marked degree, the design of the mill organisation.

As an illustration of the possibilities in this line of development, reference may be made to the mill recently erected by the Pelzer Manufacturing Company at Pelzer, S. C., U. S. A. The company had three mills containing in the aggregate 50,000 spindles, and grouped about the mill was the village with tenements, schools, churches, stores, and other conveniences for the operatives. The company desired to extend their plant, and in anticipation of this had purchased a large tract of land with water power, some two miles and a half below the original mills.

Their plan was to erect a mill at the site of the water power, but it was found that such a location would involve expensive foundations and a large outlay to render the site available for a large mill.

After a careful study of the question, it was decided to develop the water power at the most available point and erect the mill near the original mills on a site which was peculiarly advantageous so far as construction was concerned, and transmit the power by electric transmission from the water power two and one-half miles below, to the mill.

By doing this the cost of constructing the mill building was not only very much less, but many of the advantages of the town already in existence were available for the new mill, and the expense of a railroad to the lower site was avoided.

It is not claimed in this paper that at the present time electric transmission is universally applicable, but it may be claimed with propriety that under certain conditions the advance in the manner of transmitting power has made it possible to exercise much greater freedom in designing and organising the modern cotton mill.