A TREATISE

ON

MILLS AND MILL-WORK.

SECTION I.

INTRODUCTION.

CHAPTER I.

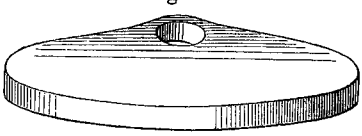
EARLY HISTORY OF MILLS.

We may search in vain for dates from which to calculate the earliest period at which the principles of accumulating power, and transmitting it for employment in mills, were first introduced, and it is equally impossible to trace consecutively the progressive developments that have taken place from the days of antiquity to the present improved state of the arts. Perhaps the earliest introduction of machinery was in the processes for the preparation of food, as we read of the Egyptians and Babylonians, and other nations in Europe and Asia, having mills for grinding corn at the earliest periods at which there are records of their history. Hesiod and Pliny both describe the most primitive method of the preparation of corn, a method still further illustrated among the pictorial remains of the Egyptians, viz. pounding in a mortar.

Corn Mills.—When millstones were introduced is uncertain, although they boast of a high antiquity. Agatharcides (B.C. 113) mentions grinding stones employed in the reduction

of gold ore in the mines on the Red Sea, and of the same kind, no doubt, were the early flour mills. Two round stones, with concave and convex fitting surfaces, roughened or notched like the pestle in Pliny's description, so as to distribute the grain introduced through a hole in the upper stone, and to throw off the flour at the edges. A pivot in either stone, fitting a recess in the other, would be necessary to guide the upper or running stone, which would be moved by simple manual labour. Millstones of this kind, or querns, as they are commonly called, are found not unfrequently amongst the foundations of Roman villas, and along the lines of Roman encampments. Fig. 1 is a representation of the nether stone of such a mill found at Gayton, near Northampton, and figured in the Archæologia, vol. xxx. The stone of which these mills were composed, was a sort of pudding stone, or rough lava, which from its varying hardness tended to retain a biting surface. Some of the querns retain traces of the notches or "work:" they vary from ten inches to twenty inches in diameter. Usually, as at the present time in some countries, these handmills were turned by women, but amongst the Romans male slaves were employed for this purpose, or it was reserved as a penal exercise for convicts.

Fig. 1.

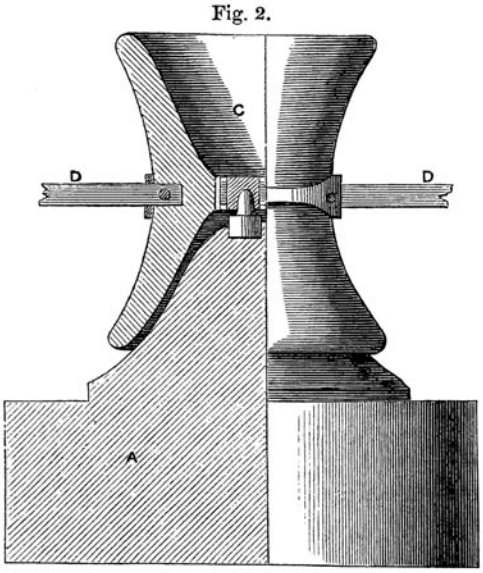


Roman Quern. Archæologia, xxx. 128.

The essential defects of this mode of grinding, the want of power, and the tediousness of the operation, led gradually to the employment of cattle mills, and these are sometimes mentioned by classical authors, although little was known of their construction until recently. In disentombing the baker's house at Pompeii, several of these large mills were found, in excellent preservation. Fig. 2 is a representation of one of them, and may be described as follows: The base A is a cylindrical stone, about five feet in diameter, and two feet high. Upon this, forming part of the same block, or else firmly fixed into it, is a conical projection, about two feet high, the sides slightly curving inwards; upon this rests another block C, externally resembling a dice-box, internally an hour-glass, being shaped into two hollow cones with their vertices towards each other,

the lower one fitting the conical surface on which it rests, but not with any degree of accuracy. To diminish friction, however, a strong iron pivot was inserted in the top of the solid cone, and a corresponding socket let into the narrow part of the hour-glass shaped stone C. Four holes were cut through the stone parallel to this pivot, the narrow part was hooped on the outside with iron, into which wooden bars D D were inserted, by means of which the upper stone was turned on its pivot by the

Fig. 2.



Pompeian Corn-Mill.

labour of men or asses. The upper hollow stone served as a hopper as well as a grinder, and was filled with corn, which fell by degrees through the four holes upon the solid cone, and was reduced to powder by friction between the two rough surfaces; of course it worked its way to the bottom by degrees, and fell out on the cylindrical base, round which a channel was cut to facilitate the collection. These machines are about six feet high in the whole, made of rough grey volcanic stone full of large crystals of leucite.*

Imperfect and tedious as the operation of grinding must still have been, cattle mills seem long to have held their ground

* Clarke, Pompeii, vol. ii. p. 136.

against further innovation, and even down almost to our own day in old works on machinery various contrivances for employing the labour of cattle in corn mills are described. However, before the Christian era a new power was beginning to be applied to corn mills, that of flowing or falling water. Probably the immense quantities of water required in Egypt and Assyria for the irrigation of the land first led to contrivances for turning to account the current of rivers as a motive power. Vitruvius describes water wheels employed both for raising water and for grinding corn *, the motion in the latter case being made available by a rude kind of gearing, in which we may trace the rudiments of our present transmissive machinery. Whittaker, in in his History of Manchester, describes a water mill ascribed to the Romans, of which traces were found in Manchester some years since. This mill served equally the purposes of the town and garrison, but was not alone sufficient, as the use of handmills remained very common in both, many having been found on the site of the station at Campfield. The Roman water mill at Manchester was placed upon the River Medlock, immediately below Campfield, and a little above an ancient ford. The sluice and conduit which actually regulated and conveyed the water to the mill was accidentally discovered about the middle of the last century. It was found at a place called Dyer's-croft, where a flood in the river swept away a dam with a large oak beam upon the edge of it, and disclosed a tunnel in the rock below. This, when excavated was found to be about three feet wide and three feet deep, gradually narrowing at the bottom, and upon the sides the marks of the tool were everywhere to be found. This ancient tunnel was bared to the extent of twenty-five yards, but it evidently had been continued in a direct line up to the commencement of a wide weir in the river above. From these discoveries it will appear that mills for grinding corn by power were of ancient date even in this country.

In our attempts to trace the progress of the mechanical arts, we are compelled to leave as a wide blank the period of intestine war which succeeded the decline of the Roman Empire. The conquest of Rome by Alaric and the spread of a race of barbarians over the whole of Europe, had the effect, for many

* Vitruvius, Architecture, book x. c. 10.

centuries, of obliterating almost every vestige of the arts which in the turmoil and tumult of war were either entirely lost or utterly neglected. Thus, for a long succession of years, during the middle ages and at the period of the Crusades, the industrial arts languished and retrograded, and it was not until the time of Michael Angelo and Galileo that mathematics, architecture, engineering and mechanics received the least encouragement or attention. The mathematician and natural philosopher had before then been looked upon with suspicion, and carefully watched as a person dangerous to society. During the rise of painting, sculpture, and architecture, the arts which rendered the republics of Italy so illustrious, mechanism began to attract notice, and to that age we may trace the introduction of water mills in many parts of Italy. Little or no progress, however, was made down to the close of the seventeenth century.

The Dutch, owing to the natural difficulties of their location, were urged, in their own defence, to take the lead in the field of mechanical appliance; and the vast embankments of that enterprising people, with their canals and docks, fully justify the remark that they were amongst the first to benefit mankind by the introduction of mills for grinding corn, which was chiefly imported, and of machines for draining the lands which their patient industry had reclaimed from the sea. As a prime mover the Dutch had no water power except what was obtained by impounding the tidal water and working it off during the reflux of the tide. At best this was an expensive and uncertain power which caused wind to come into more general use; and during the greater part of the seventeenth century we were chiefly indebted to the Dutch and Belgians for our improved knowledge of manufacture.

Mills for the Manufacture of Textile Fabrics.—Woollen, cotton, and linen cloth was manufactured in this country from an early period, and the manufacture of silk was practised in Italy in the twelfth century. It was subsequently introduced into France and other parts of Europe, and we learn that James I. encouraged the manufacture, and made an attempt to grow the mulberry and produce silk in this country, which, however, as might have been expected, totally failed. During the reign of

Charles I., the Commonwealth, and the reign of Charles II. the manufacture of silk goods made great progress, and it is stated that in 1661 as many as 40,000 persons were employed in that branch of industry. In 1685, on the revocation of the Edict of Nantes, a large colony of skilful French weavers settled at Spitalfields, and from that time to the present have carried on the manufacture in that locality. The winding, throwing, and weaving was chiefly done by hand, and it was only from the construction of the large throwing mill at Derby, in 1719, that we date introduction of mill-machinery, technically so called, in the production of these fabrics.

Woollen mills have a much greater antiquity than either silk or cotton mills. Spinning and weaving processes were known in the time of Moses and are illustrated in ancient Egyptian monuments. Pliny attributes the discovery of the art of fulling cloth to Nicias of Megara (B.C. 1131). The origin of the woollen manufacture is evidently beyond the reach of tradition, though the process of felting was probably known before the art of spinning and weaving. Amongst the Romans the woollen manufacture attained considerable perfection, and several of their writers describe the different qualities of cloth as used for the tunic and common stuff garments.

From the time of the Romans until the Norman Conquest we have no record of the manufacture of woollens, and it is certain that amongst the Saxons, and, indeed, for several centuries after the Conquest, the costume of the peasantry was of leather, and there is reason to believe that the "buff-jerkin" retained its place as the ordinary dress of the labouring people of England until the time of the Commonwealth.

It is generally supposed that the woollen manufacture was introduced into this country in the reign of Edward III., but there is every reason to believe that it existed long before that time. Mr. McCulloch states that it was practised above a hundred years before that prince introduced improvements in the manufacture. What these improvements were is not known; probably they were neither more nor less than protective laws, which by giving an increased monopoly to guilds and corporations, seriously injured the freedom and restricted the extension of trade.

The whole of the woollen mills, from a very early period to the commencement of the present century, were driven by water, and this will account for the locations on the streams of the west of England and Yorkshire, where the woollen manufacture was carried on. The introduction of improved machinery for the manufacture of cotton gave to the woollen trade an entirely new character; and from that circumstance we may safely date the vastly increased production and the great extension that has taken place in that important branch of manufacture.

The next article of importance in an historical point of view is cotton; and to this production we may safely trace the advancement, prosperity, and power of the British Empire. The cotton manufacture had its origin in India, where the plant is indigenous, and where the climate renders a light absorbent fabric the most suitable clothing for the inhabitants. The manufacture of cotton in India may be dated from a period antecedent to the Romans; and the implements used in the different processes of the manufacture, from the cleaning of the wool to its conversion into muslin, are of a most simple kind and may be purchased for a few shillings.

The cotton manufacture of China is of the same character as that of India; and although of immense extent, the articles produced are chiefly employed for home consumption. The arts in that country, as far as we know from the accounts of the missionaries and the more recent expedition of Lord Elgin, are stationary; and the tools, implements, &c. are of the same primitive kind as those used in India. The chief description of cotton goods exported when the Chinese became famous for their manufacture were nankeens; but these have long since given way to the cheaper productions of Great Britain, and for years past we have supplied the Chinese with large quantities of yarn and cloth.

The first introduction of cotton into Europe and its manufacture were first attempted by the commercial states of Italy; and as early as 1560 cottons were exported from Venice to the different markets of Europe in the West. It was not, however, until the beginning of the seventeenth century that cotton was manufactured in this country; but we have records that the town of Manchester bought cotton wool in London which came

from Cyprus and Smyrna, and worked the same into fustians, vermilions, and dimities. These goods were woven chiefly at Bolton, and finished by the Manchester dealers.

It is curious to trace the progressive increase of any description of manufacture, particularly that of cotton, which has attained to such colossal dimensions. In early times the weaver provided his own warp, which was of linen yarn, and cotton for his weft; buying these where he could best supply himself. In this way, every cottage formed an independent factory; the cotton was carded and spun by the female part of the family, and the cloth woven by the father and his sons.

Such was the state of the cotton manufacture before the introduction of power machinery, and the division of labour, and the separation of the different processes into distinct employments. At this time the workman had usually his residence in the country, where, with a little garden and perhaps grass for a cow, he carried on his trade and earned a comfortable subsistence. "How much more," says a philanthropic writer, "of the comforts of life and of the means of natural enjoyment belong to this state of manufacture than to the more advanced in which combined systems of machinery and a more perfect division of labour collect the workmen into factories and towns."

It will not be necessary to enumerate here the wellknown improvements of Arkwright, Hargreaves, and Crompton, or the changes which followed the introduction of machines for carding, roving, and spinning. Suffice it to observe, that these improvements inaugurated a new system of operations, and created a new demand for power and the means of transmitting it to the different machines required in the manufacture. It was about this time and at a rather later period that the improvements of the motive power and machinery of transmission were introduced.

To the steam engine in the first place, and subsequently to the improved machinery and mill-work, we may attribute the present gigantic extent of our manufactures. The factory system, which has supplanted the cottage manufacture, has enlarged the resources of the country far beyond those of any former period. This island stands pre-eminent in productive industry,

and it is a source of pride and gratification to find that these blessings, springing out of the application of physico-mechanical science, have been attained by the skill and indomitable perseverance of our own countrymen.

To the immediate action, foresight, and intelligence of the Government of this country, the workers in coal, iron, and cotton are under no obligation; but they owe much to their own invention, skill, and industry in the prosecution and development of these pursuits, and the only merit that can be claimed by the Government is its non-interference and the protection it affords through the laws of the kingdom, which give security to property and to individual exertion in the varied departments of productive industry. Further, Dr. Ure, in his "Philosophy of Manufactures," argues that "the constant aim of scientific improvements in manufactures, is philanthropic, as they tend to relieve the workman either from niceties of adjustment, which exhaust his mind, or from painful repetition of efforts which distort or wear out his frame." Illustrations of this truth are presented every day in the remarkable extent to which labour is saved, with superior beauty and precision in the result, by self-acting machines, all of them within the domain of Automatic science.

The division of labour carried out by means of the factory system, is not exclusively applied in the manufacture of cotton, flax, silk, and woollen cloths; it pervades almost the whole of our manufacturing industry, and is beginning to show itself in mining and agriculture, and the time is probably not far distant, when we shall witness almost every operation of the human hand carried on by a system of divided activity, equally conducive to the interests of individual enterprise and to the public benefit.

The term *Factory*, according to Dr. Ure, designates, "the combined operation of many orders of work people, adult and young, tending with assiduous skill, a system of productive machines, continuously impelled by a central power. This definition includes cotton mills, flax mills, silk mills, woollen mills, and certain engineering works, but it excludes those in which the mechanisms do not form a connected series, or are not dependent upon one prime mover." The factory system is

so much extended since these words were written as to change the relations of labour, and to affect almost every manufacturing process. It has created a much higher and more intelligent class of workmen than existed under the hand system, more respectable, better paid, better housed, and better clothed than heretofore.

IRON MANUFACTURES.—We are at the present time in a state of transition in the manufacture of iron and steel, which is making rapid strides towards improvement. The inventive talent of the country has been directed to this object, and the production of homogeneous plates, having the elasticity and tenacity of steel, together with the improvements of Mr. Bessemer, Mr. Clay, and others, are likely to produce a complete revolution by a greatly increased economy in the production of iron. Mr. Bessemer is now proposing to roll plates in the form of a continuous web from liquid metal, run direct from the furnace to the rolls. We cannot vouch for the success of this enterprise, but we are most anxious to see its results realised, and there cannot exist a doubt from the number of able chemists and practical men at work, that the iron trade of this country is calculated to undergo a great change, and perhaps with as much benefit as was accomplished by Mr. Cort on the introduction of the puddling and rolling processes.

In the machinery department of iron manufacture there is nothing to boast of; it is still crude and rough in its character, perhaps necessarily so, on account of its liability to breakage in rolling, and other processes requiring great power. It is, however, possible, that the processes now in progress, may introduce new and more perfect machinery into the manufacture, and that the iron master may calculate with the same certainty of continued progress in his manufacture as now exists in other trades where machinery is employed.

Although much change has not been effected in the machinery of the iron manufacturer, considerable improvements have nevertheless been made in the smelting of the ores, and since the introduction of hot blast by Mr. Neilson the production of the furnaces has been more than doubled. Looking forward, therefore, to the improvements and changes now in