II.—*Description of the Pan-chakí or Native Water-mill.*

On the mountain streams and rivers in the Northern *Doáb*, the Natives use a water-mill for grinding corn, which for its simplicity is well deserving attention, as it might be applied in all countries, where a fall of water can be commanded, and where a want of efficient workmen renders the complicated and expensive species of mill machinery, generally used, a matter of difficulty to manage or keep in repair. In the hands of the Natives and with the rude means that they have by them, it may be perhaps considered the only sort of mill that could be turned to any account, both from the absence of any complication in its parts, and from the simplicity of its construction, rendering it in any man's power for a trifling outlay, either to fix his mill at any point that may suit him, or to remove it at pleasure; the only weighty parts about it being the mill-stones, which however by running a stick through them, and yoking a bullock or pair of bullocks to them, may in the neighbourhood of roads or common tracks be also removed with as little difficulty or expense as the rest of the machinery.

A horizontal water-wheel with floats placed obliquely so as to receive a stream of water from a shoot or funnel, the said float-boards being fixed in a vertical axle passing through the lower mill-stone, and held to the upper one by a short iron bar at right angles, causing it to revolve with the water-wheel;—the axle itself having a pivot working on a piece of the hardest stone that can be procured from the shingle near at hand:—this with a thatched roof over it, and the expense and trouble of digging a cut so as to take advantage of a fall of water,—are the only articles required in this very simple mill. The plan is so obviously good, not only for the means gained, but also from the simplicity rendering the whole almost independent of repair, and so intelligible in its parts as to come within the comprehension of the simplest understanding, that it has been adopted generally in all the canals in the Delhi district, as well as in those of the *Doáb*; and with such success, that the introduction of such mills, wherever sufficient fall is provided, is as much an object, on account of the profit arising to the canal returns, as from the accommodation and convenience offered to the community, in providing the means for grinding corn.

On reference to the accompanying plate, it will be seen that there is only one motion, and that supposing the materials are good, the permanency of the machinery depends entirely on the lower pivot. It will also be evident that there is not a part of the whole machinery that could not be repaired and put in perfect order by the commonest village

workman, a matter of importance in the absence of mechanical skill and practised workmen. Whereas in the plainest undershot wheel applied to a mill for grinding corn, there are no less than three wheels of different descriptions; the change of vertical to horizontal motion;—and three pivots to keep in order, with a friction, even under the most skilful management, tending constantly to disarrange the parts, and render the accompaniments of a forge and blacksmith's shop absolutely necessary to keep the mill in order.

On the canals it has been found worth while to construct permanent buildings for these corn mills*, and although keeping most strictly to the original simplicity of the machinery, they are set up with greater care, and means are given for regulating the motion, &c. which renders the whole as perfect as it can well be.

It would appear that a fall of water (that is to say, the difference of level between the surface of the head supply and the float-boards of the water wheel), equal to three feet, is the minimum in which this species of machinery can be used with any good effect; and it has been found that with a fall of three feet, the dimensions of the shoot or funnel require an addition in width, to obtain that by weight of water, which the smallness of the fall will not give by velocity alone, and in the dimensions of shoot given to those of a higher class.

The following are the particulars of mills on the *Doáb* canal, divided into three classes from the depth of the fall; the width of shoot on the sill or waste-board, being 12 inches, and the discharge per second averaging 6.5 cubic feet: the diameter of mill-stones 27 inches, and thickness 12 inches;—the corn being ground into *atta* or coarse flour.

Class.	*Fall of water.* ft.	in.	*Atta ground per hour.* md.	seer.
No. 1	7	6	1	26
2	5	6	1	5
3	3	6	0	17

The common mills used in the Jumna and mountain-streams, are said to grind from 5 to 7 maunds of *atta* per day, or in 24 hours; the machinery being of the rudest description, the supply of water very small, and a great part of that escaping through the shoot before it touches the water wheel.

The return to Government on the mills is obtained generally by farming them out to contractors for fixed periods, who pay so much per day as long as a supply of water equal to that entered in the contract is provided, regulated by the depth of water on the sill or

* Vide Major Colvin's Report, p. 121.

waste-board; this return of course varies not only from the powers of the mill, but also from their position relatively to populous towns and cantonments. In the neighbourhood of Delhi the return is great, and demand for *atta* equally so; whereas at other points distant from towns, mills of equal power would not produce half the return. The *Doáb* canal, although possessing every advantage in fall and power of machinery, labors under a disadvantage in this respect, the town of *Sahárunpur* being the only one throughout its whole extent where there is any great demand for machinery of this description. *Shámli*, although a large town, does not contain a great number of that class of people who purchase *atta*, each family grinding their own corn for home consumption; and although there are ample means for establishing mills at the south end of the canal opposite Delhi, (the canal falling into the *Jumna* with a descent of about 50 feet in a line of 12 miles!) it has been considered unadvisable to put them in extended practice, on the supposition that the mills already built on the Delhi canal in the city would suffer from the competition;—in short, that the mills *in* Delhi are sufficient to grind the corn *required* by its population.

The people from whom the millers look for profit are chiefly those of the *sipahi* class, travellers, those without families, idlers, &c. those who are regularly settled with their families, trusting as I before said to the hand-mill in their own house, and not purchasing from the mills excepting on marriages and other grand occasions, when the consumption of *atta* is more than their own mill could provide for. In military cantonments the whole of the *atta* and flour used is obtained from the mills; the vicinity therefore of a station of this description becomes a lucrative affair to the miller, in exemplification of which I may mention, that during the existence of the Provincial Battalion at *Sahárunpur*, the canal mills at that place were kept constantly in their service, with little or no aid from the inhabitants of the town.

The profit derived by the renter of a mill depends in a great measure on his management, and on the rate per maund which he charges for grinding; but with an experienced and steady man, the following may be considered as a very close approximation to their daily profit. The rate per maund for grinding *atta* by the *Peesunyaris* or corn-grinders in the city, is generally three annas, for which sum they deliver the articles at the purchaser's house; at the water-mills two annas per maund is the usual charge, not however including the carriage of the grain to the mill, &c. the charge of two annas being simply for grinding.

The expenses to the miller for keeping 2 mills at work are thus,

Per month,	1 head miller's wages, ... Rs.	5	0	0
	1 assistant ditto ditto, ...	4	0	0
	1 weighman, ...	4	0	0
	Oil at ¼ seer per day, about	1	0	0
	2 seers of *atta* given per day to 2 millers, in addition to their regular pay, about	2	7	0
	Total expense per month, Rs.	16	7	0
	or per day, taking a month of 30 days, ...	0	8	9 1/5

The receipts per day are as follows:

Supposing 55 mds. of grain ground at 2 ans. per md.				6	14	0
DEDUCT.						
Expenses as above, ...	0	8	9 1/5			
Government rent, ...	5	0	0			
				5	8	9 1/5
Balance of profit to miller per day, Rs.				1	5	2 1/5

The above daily expenses would not be increased by an additional mill;—the profits to the contractor in that case could therefore be much increased; whereas a solitary mill would very nearly require the same establishment, and would therefore be less profitable; mills of a higher power also might be easily worked with the above scale of establishment.

At mills distant from towns, the payment for grinding corn is made in kind, varying from 2 to 4 seers per maund, which, at the usual rate of from 40 to 50 seers per rupee, is but a moderate return in comparison with that at the town mills. These village mills grind gram, barley, and Indian corn, as well as wheat.

The stones used on the canals are chiefly those from the quarries near *Agra*, *Rúpbas*, and *Fatihpur Sikri*, a coarse-grained sandstone which requires the chisel every second day,—there are three sizes used;

First size, diameter 36 inches, depth 12
Second ditto, — 30 inches, do.
Third ditto, — 27 inches, do.

The two latter are in most general use. Stones of the usual quality last for about 2 or 3 years, that is to say, at the end of that period a new upper stone is provided, and the old one placed below. In the native mills on the *Jumna*, stones about 22 inches diameter, and from 10 to

12 inches thick, are quarried in the vicinity of *Rájpur* north of *Dehrah*; they appear to me of an inferior description, though of various qualities;—the native millers, however, prefer some of them to the *Agra* stone, and it is not impossible that some of the best variety from *Rájpur* may be superior to the worst from *Agra*, but generally speaking the preference is decidedly in favor of the latter.

The best method of delivering the water from the shoot on to the float-boards, appears to be that represented in the accompanying sketch, and which has been generally practised on the canals in pursuance of the usual course adopted by the natives. A trial made at Hansi, in which a horizontal (or nearly horizontal) shoot applied to the lower part of a cistern delivered the stream on float-boards whose planes were parallel to the axis of the arbor or upright, did not answer so well as was expected, owing in a great measure, it was supposed, to the introduction of a new system, which unless palpably advantageous, is certain to meet with objections from the people to whom the mills are entrusted; but although the limits of this paper will not allow me to enter into a discussion on the point in question, I am much inclined to consider that the latter method is not only objectionable, but that the power obtained in applying it to this simple water-wheel is much less than the other; a matter to be settled by practical experiments, and not by theoretical speculations. Belidor, in speaking of a mill of this description, says, "En Provence et dans une bonne partie du Dauphiné, les moulins y sont d'une grande simplicité, n'ayant qu'une roue horizontale, de 6 ou 7 pieds de diametre, dont les aubes sont faites en *cuillerès** pour recevoir le choc de l'eau, qui coule ordinairement dans un auge; L'arbre, qui repond à la meule supérieure, est la seule piece qui sert á lui communiquer le mouvement, et je ne crois pas qu'il soit possible de faire un moulin à moindre frais; il est vrai qu'il faut pouvoir menager une chute comme celle que l'on voit ici, et qui sont tres frequentes dans ce pays là.

"La roue tourne sur un pivot dans une crapaudine pratiquée au milieu de l'entretoise du chassis, servant à approcher les deux meules, par le moyer de la vis se qui est a l'extremité de la piece, et de l'ecrou, que l'on fait tourner pour hausser ou baissir le chassis.

"Les roues que l'on voit exécutées danse la gont de cell ci ont leur cuillères simplement assemblées a l'arbre par un tenon et une cheville,

* These cuillères, or spoon-shaped ends, are mere indentations in the native mills, and the trough alluded to by Belidor for the delivery of the water at an angle of about 25° is in the native mills a square tube or shoot placed at an angle of 45°. The crapaudine and the arrangement for raising or depressing the upper stone by the transom in which it is fixed, is also practised in the native mill.

fortifiées par le dessous par des membrures qui les entretiennent toutes ensembles." He goes on to explain a method of opening and shutting the water-course or shoot, which is of no consequence here. It will be seen however, that this mill is exactly on the same plan as that used in this part of India, and it is a pity that the account did not proceed and explain the powers of the mill, that we might draw a comparison. It would also be interesting to know whether the increased size (the Provence mill being about double the size in diameter of water-wheel, &c.) would not detract from the simplicity of the little native mill; for the great advantage of the latter appears to be the absence of complicated wood and iron-work, especially joints and iron bindings, &c. all of which increase with length of lever, or length of radii of the water-wheel: indeed the above account shews a complication of *membrures*, &c. which in the native mill are not thought of.

Northern Doab, April 30, 1833.

Reference to Plate XII.

Fig. 1. Elevation of the water-wheel, with the stones in section to represent the iron spindle.

At *x*, a hole of about 4 inches diameter and 4 inches deep is made in the transom, into which a quartz boulder is firmly fixed; the said stone or boulder having an indentation made in it to receive the pivot.

This pivot, as represented in fig. 4, consists of another stone of the same quality of about 4 or 5 inches long and 1 inch square, which is firmly fixed into the tail of the arbor, (see *y*.) The above stones are picked up in the beds of the mountain rivers, and are used as they are found without any stone cutting.

Fig. 2. Plan of water-wheel, 30 float boards of sissú wood.

Fig. 3. Upper joint of arbor.

Fig. 4. Lower joint of ditto, shewing the iron straps fixed between each float board, to keep them firmly in position, the strap represented in fig. 5.

Fig. 5. Strap as above.

Figs. 6 and 7. Float board and end of ditto; the float board 12 inches long, with a spoon sunk 4 inches.

Fig. 8. Iron ring that slips over the top of arbor, and holds the two joints together.

Figs. 9 and 10. The spindle and plate upon which the upper mill-stone turns.

Fig. 11. Sketch of mill stones with basket stand, &c.

a. Hopper or basket.

b. Shoe.

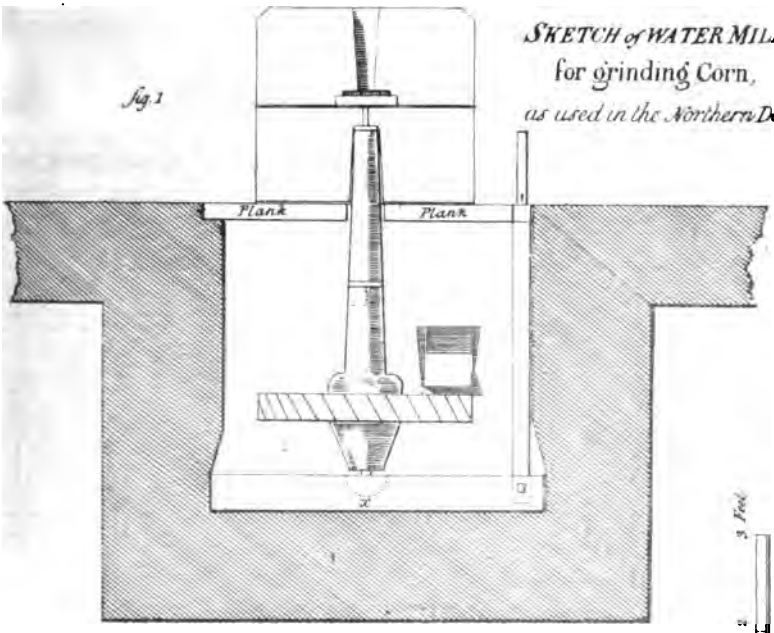
c. Feeder, or small piece of wood hanging to one lip of the shoe, and resting on the mill-stone, each revolution of which gives the shoe a jog, causing the corn to run constantly from the hopper through the shoe.

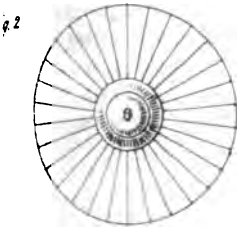
d. String attached to the opposite lip of the shoe, to which the feeder is, and by tightening or loosening which, the discharge of corn is regulated.

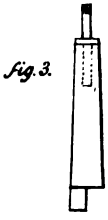
e. Stand.

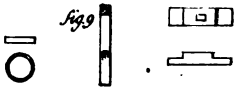
Fi. 12. Shoe on a large scale: this is generally cut out of a block of *dak* (Butea frondosa), or any wood easily worked.

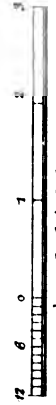
SKETCH of WATER MILL for grinding Corn, as used in the Northern Doab.

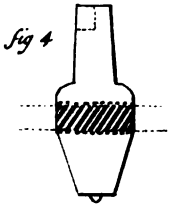












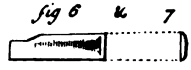


fig 11. Scale ½ Inch to 1 Foot.

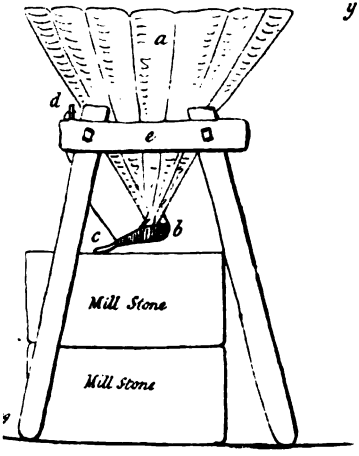


fig 12
Scale of ½ In to 1 Foot.