PART THE FOURTH.

On the Process of manufacturing Grain into Flour, as practised by the most skilful Millers in the United States.

CHAPTER XIII.

ARTICLE 104.

THE PRINCIPLES OF GRINDING EXPLAINED, TOGETHER WITH SOME OBSERVATIONS ON LAYING OUT THE FURROWS IN THE STONES WITH A PROPER DRAUGHT.

THE end we have in view in grinding the grain, is to reduce it to such a degree of fineness, as is found by experience to fit it to make the best bread; and to put it in such a state, that the flour may be most effectually separated from the bran, or skin of the grain, by means of sifting or bolting. It has been proved by experience, that to grind grain fine with dull mill-stones, will not answer said purpose, because it kills or destroys that quality of the grain, which causes it to ferment and raise in the baking; it also makes the meal so clammy, that it sticks to the cloth, and chokes up the meshes in bolting; hence it appears, that it should be made fine with as little pressure as possible; and it is evident that this cannot be done without sharp instruments. Let us suppose we undertake to operate on one single grain, it seems to accord with reason, that we should first cut it into several pieces, with a sharp instrument, to put it into a state suitable for being passed between two planes, in order to its being reduced to one regular degree of fineness. The

planes should have on their faces a number of little sharp edges, to scrape off the meal from the bran, and should be set at such a distance apart as to reduce the meal to the required fineness, and no finer; so that no part can escape unground. The same rules or principles will apply to any quantity that will serve for one grain.

To prepare the stones for grinding to the greatest perfection, we may conclude, therefore, that their faces must be put into such order, that they will first cut the grain into several pieces, and then pass it between them in such a manner, that none can escape without being ground to a certain degree of fineness, whilst, at the same time, it scrapes the meal off cleanly from the bran or skin.

The best way that I have yet found to effect this, is (after the stones are faced with the staff, and the pick,) to grind between them a few quarts of fine, sharp sand; this will face them to fit each other so exactly, that no meal can pass them without being ground; this is also the best way of sharpening all the little edges on the face, that are formed by the pores of the stone; instead of sand, water may be used, the stones then face each other; they will then scrape the meal off of the bran, without too much pressure being applied. But as the meal will not pass from the centre to the periphery or verge of the stones, with sufficient rapidity, without some assistance, there must be a number of furrows, to aid it in its egress; and these furrows must be set with such a draught that the meal will not pass too far along them at once, without passing over the land, or plane, lest it should get out unground. They should also be of sufficient depth, to permit air enough to pass through the stones to carry out the heat generated by the friction of grinding; but if they have too much draught, they will not bear to be deep, or the meal will escape along them unground. These furrows ought to be made sharp at the feather edge, which is the hinder edge of the furrow, and the foremost edge of the land; this serves the purpose of cutting down the grain; they should be more numerous near the centre, because there the office of the

stone is to cut the grain, and near the periphery the office of the two planes is to reduce the flour to the required fineness, and scrape the bran clean, which is effected by the edges, formed by the numerous little pores with which the burr stone abounds. We must consider, however, that it is not best to have the stones too sharp near the eye, because they then cut the bran too fine. The stones incline to keep open near the eye, unless they be too close. If they be porous, (near the eye,) and will keep open without picking, they will remain a little dull, which will flatten the bran, without cutting it too much: but if they be soft next the eye, they will keep too open, and that part of the stone will be nearly useless; they, therefore, should be very hard and porous.

It is also necessary, that the face of the stone be dressed in such a form, as to allow room for the grain, or meal, in every stage of its passage between the stones. In order to understand this, let us conceive the stream of wheat entering the eye of the stone, to be about the thickness of a man's finger, but instantly spreading every way over the whole face of the stone; this stream must, therefore, get thinner, as it approaches the periphery, where it would be thinner than a fine hair, if it did not pass slower as it becomes finer, and if the stones were not kept apart by the bran; for this reason, the stones must be so dressed, that they will not touch at the centre, within about a 16th or 20th part of an inch, but get closer gradually, till within about 10 or 12 inches from the verge of the stone, proportioned to the diameter, and from that part out they must fit nicely together. This close part is called the flouring of the stone. The furrows should be deep near the centre, to admit wheat in its chopped state, and the air, which tends to keep the stones cool.

ARTICLE 105.

OF THE DRAUGHT NECESSARY TO BE GIVEN TO THE FURROWS OF MILL-STONES.

From these principles and ideas, and the laws of central forces, explained at Art. 13, I form my judgment of the proper draught of the furrows, and the manner of dress; points in which I find but few of the best millers to agree; some prefer one kind, and some another, which shows that this necessary part of the miller's art is not yet well understood. In order to illustrate this matter, I have constructed fig. 3, Plate XI. A B represents the eight quarter, C D the twelve quarter, and E A the central dress. Now, we observe that in the eight quarter dress, the short furrows at F have about five times as much draught as the long ones, and cross one another like a pair of shears opened so wide that they will drive all before them, and cut nothing; and if these furrows be deep they will drive out the meal as soon as it gets into them, and thereby make much coarse meal, such as middlings and ship stuff or carnel; the twelve quarter dress appears to be better; but the short furrows at G have about four times as much draught as the long ones, the advantage of which I cannot perceive, because if we have once found the draught that is right for one furrow, so as to cause the meal to pass through the stone in a proper time, it appears reasonable that the draught of every other furrow should be equal to it.

In the central dress E A, the furrows have all one draught, and if we could once determine exactly how much is necessary, I have no doubt we should find this to be the correct plan; and I apprehend that we shall find the best draught to be in a certain proportion to the size and velocity of the stone; because the centrifugal force that the circular motion of the stones gives the meal, has a tendency to move it outward, and this force will be in inverse proportion to the diameter of the stones, their velocities being the same, by the fourth law of circular

motion. E e is a furrow of the running stone, and we may see by the figure, that the furrows cross one another at the centre at a much greater angle than near the periphery, which I conceive to be right, because the centrifugal force is much less towards the centre than near the periphery. But we must also consider, that the grain, whole or but little broken, requires less draught and centrifugal force to send it out, than it does when ground fine; which shows that we must not, in practice, follow the theory laid down in Art. 13, respecting the laws of circular motion and central forces; because the grain, as it is ground into meal, is less affected by the central force to drive it out; the angles, therefore, with which the furrows cross each other, must be greater near the verge or skirt of the stone, and less near its centre than would be assigned by that theory; and what ought to be the amount of this variation is a question which practice has not yet determined.

From the whole of my speculations on this difficult subject, added to observations on my own and others' practice and experience, I propose the following rule for laying out a five foot mill-stone. (See fig. 1, Plate XI.)

1. Describe a circle with 3 inches, and another with 6 inches radius, round the centre of the stone.
2. Divide the 3 inches space between these two circles into 4 spaces, by 3 circles equi-distant; call these five circles draught circles.
3. Divide the stone into 5 parts, by describing 4 circles equi-distant between the eye and the verge.
4. Divide the circumference of the stone into 18 equal parts, called quarters.
5. Then take a straight-edged rule, lay one end at one of the quarters at 6, at the verge of the stone, and the other end at the outside draught circle, 6 inches from the centre of the stone, and draw a line for the furrow from the verge of the stone to the circle 5: then shift the rule from draught circle 6, to the draught circle 5, and continue the furrow line towards the centre, from circle 5 to 4: then shift in the rule to draught circle 4, and continue to 3; shift to 3, and continue to

2; shift to 2, and continue to 1, and the curve of the furrow is formed, as 1—6 in the figure.

6. To this curve form a pattern, by which to lay out all the remainder.

The furrows with this curve will cross each other with the following angles, shown fig. 1,

at circle 1, which is the eye of the stone, at 75 degrees angle,

—	2	-	-	45	——
—	3	-	-	35	——
—	4	-	-	81	——
—	5	-	-	27	——
—	6	-	-	23	——

These angles, as shown by the lines G r, H r, G s, H s, &c. &c., will I think, do well in practice, will grind smooth, and make but little coarse meal, &c.

Supposing the greatest draught circle to be 6 inches radius, then, by theory, the angles would have been

at circle	1	-	-	138	degrees angle.
—	2	-	-	69	——
—	3	-	-	46	——
—	4	-	-	35,5	——
—	5	-	-	27,5	——
—	6	-	-	23	——

If the draught circle had been 5 inches radius, and the furrows straight, the angles would then have been at

	circle.		degrees.
	1	about	180
And 6 inches from centre, as shown by lines G 1, H 1,		—	110
	2	—	60
	3	—	38
	4	—	29
	5	—	23
	6	—	18

Here, the angles near the centre are much too great to grind, and they will push the grain before them; to remedy this disadvantage, take the aforesaid rule, which forms the furrows, as shown at 6—7, fig. 1, which is 4 of 18 qrs. H 8 represents a furrow of the runner, show-

ing the angles where they cross those of the bed-stone, in every part. Here I have supposed the extremes of the draught of 6 inches for the verge, and 3 inches for the eye of the stone, to be right for a stone 5 feet diameter, revolving 100 times in a minute; but of this I am, by no means, certain. Yet, by experience the extremes may be ascertained for stones of all sizes, with different velocities; no kind of dress of which I can conceive, appears to me likely to be brought to perfection excepting this, and it certainly appears, both by reason and by inspecting the figure, that it will grind the smoothest of all the different kinds exhibited in the plate.

The principle of grinding is partly that of shears, clipping; the planes of the face of the stones serving as guides to keep the grain in the edge of the shears, the furrows and pores forming the edges; if the shears cross one another at too great an angle, they cannot cut; it follows, therefore, that all the strokes of the pick should be parallel to the furrows.

To give two stones of different diameters the same draught, we must make their draught circles in direct proportion to their diameters; then the furrows of the upper and lower stones of each size, will cross each other with equal angles in all proportional distances, from their centres to their peripheries. But when we come to consider that the mean circles of all stones are to have nearly equal velocities, and that their centrifugal forces will be in inverse proportion to their diameters, we must perceive that small stones must have much less draught than large ones, in proportion to their diameters. (See the proportion for determining the draught, Art. 13.)

It is very necessary that the true draught of the furrows should be determined to suit the velocity of the stone, because the centrifugal force of the meal will vary, as the squares of the velocity of the stone, by the 5th law of circular motion. But the error of the draught may be corrected, in some measure, by the depth of the furrows. The less the draught, the deeper must be the furrow; and the greater the draught, the shallower the furrow, to prevent the meal from escaping unground;

but if the furrows be too shallow, there will not a sufficient quantity of air pass through the stones to keep them cool. But in the central dress the furrows meet so near together, that they cut the stone too much away at the centre, unless they be made too narrow; I, therefore, prefer what is called the quarter dress, but divided into so many quarters, that there will be little difference between the draught of the furrows; suppose 18 quarters in a 5 foot stone, then each quarter takes up about 10½ inches of the circumference of the stone, which suits for a division into about 4 furrows and 4 lands, if the stone be close; but, if it be open, 2 or 3 furrows to each quarter will be enough. This rule will give 4 feet 6 inch stones, 16; and 5 feet 6 inch stones, 21; and 6 feet stones, 23 quarters. But the number of quarters is not very important; it is better, however, to have too many than too few. If the quarters be few, the disadvantage of the short furrows crossing at too great an angle, and throwing out the meal too coarse, may be remedied, by making the land widest next the verge, thereby turning the furrows towards the centre, when they will have less draught, as in the quarter H I, fig. 3.

ARTICLE 106.

OF FACING MILL-STONES.

The burr mill-stones are generally left in such face by the maker, that the miller need not spend much labour and time on them with picks, before he may hang them, and grind them together with water or dry sand. After they have been ground together for a sufficient length of time, they must be taken up, and the red staff tried over their faces,* and if it touch in circles, the project-

* The red staff is made longer than the diameter of the stones, and three inches thick on the edge, which is made perfectly straight; on this is rubbed red clay, mixed with water, which shows the highest parts of the faces of the stones, when rubbed over them, by leaving the red on those high parts.

ing parts should be well cracked with picks, and again ground with a small quantity of water or sand; after this, take them up, and try the staff on them, picking off the red parts as before, and repeat this operation, until the staff will touch nearly alike all the way across, and until the stone comes to a face in every part, that the quality thereof may plainly appear; then, with a red or black line, proceed to lay out the furrows, in the manner determined upon, from the observations already laid down in the last article. After having a fair view of the face and quality of the stone, we can judge of the number of furrows most suitable, observing that where the stone is most open and porous, fewer furrows will be wanted; but where it is close and smooth, the furrows ought to be more numerous, and both they and the lands narrow, (about $1\frac{1}{8}$ inches wide,) that they may form a greater number of edges, to perform the grinding. The furrows, at the back, should be made nearly the depth of the thickness of a grain of wheat, but sloped up to a feather edge, not deeper than the thickness of a finger-nail;* this edge is to be made as sharp as possible, which cannot be done without a very sharp, hard pick. When the furrows are all made, try the red staff over them, and if it touch near the centre, the marks must be quite taken off about a foot next to it, but observing to crack lighter the farther from it, so that when the stones are laid together, they will not touch at the centre, by about one-twentieth part of an inch, and close gradually, so as to touch and fit exactly, for about 10 or 12 inches from the verge. If the stones be now well hung, having the facing

* For the form of the bottom of the furrow, see fig. 3, Plate XI. The curve line e b shows the bottom, b the feather edge, and e the back part. If the bottom had been made square at the back, as at e, the grain would lie in the corner, and by the centrifugal force, would work out along the furrows without passing over the lands, and a part would escape unground. The back edge must be sloped for two reasons: 1st, that the meal may be pushed on to the feather edge; 2dly, that the furrow may grow narrower, as the faces of the stones wear away, to give liberty to sharpen the feather edge, without making the furrows too wide. Fig. 5 represents the face of two stones, working together, the runner moving from a to d. When the furrows are just over each other, as at a, there is room for a grain of wheat; when they move to the position of b, it is flattened, and at c, is clipped in two by the feather edges, and the lands or planes operate on it, as at d.