

## CHAPTER XXI.

## ARTICLE 129.

DIRECTIONS FOR CONSTRUCTING UNDERSHOT WHEELS,  
SUCH AS SHOWN IN FIGURE 1, PLATE XIII.

1. Dress the arms straight and square on all sides, and find the centre of each; divide each into 4 equal parts on the side; square, centre, scribe, and gauge them from the upper side across each point, on both sides, 6 inches each way from the centre.

2. Set up a truckle or centre-post, for a centre to frame the wheel on, in a level piece of ground, and set a stake to keep up each end of the arms level with the truckle, of convenient height to work on.

3. Lay the first arm with its centre on the centre of the truckle, and take a square notch out of the upper side 3-4ths of its depth, wide enough to receive the 2d arm.

4. Make a square notch in the lower edge of the 2d arm, 1-4th of its depth, and lay it in the other, and they will joint, standing square across each other.

5. Lay the 3d arm just equi-distant between the others, and scribe the lower arms by the side of the upper, and the lower edge of the upper by the sides of the lower arms. Then take the upper arm off and strike the square scribes, taking out the lower half of the 3d arm, and the upper half of the lower arms, and fit and lay them together.

6. Lay the 4th arm on the others, and scribe as directed before; then take 3-4ths of the lower edge of the 4th arm, and 1-4th out of the upper edge of the others, and lay them together, and they will be locked together in the depth of one.

7. Make a sweep-staff with a gimlet hole for the centre at one end, which must be set by a gimlet in the centre of the arms. Measure from this hole half the diameter of the wheel, making a hole there, and another the depth of the shrouds towards the centre, making each edge of this sweep at the end next the shrouds, straight

towards the centre hole, to scribe the ends of the shrouds by.

8. Circle both edges of the shrouds by the sweep; dress them to the proper width and thickness; lay out the laps 5 inches long; set a gauge to a little more than one-third their thickness; gauge all their ends for the laps from the outsides; cut them all out but the last, that it may be made a little longer, or shorter, as may suit to make the wheel the right diameter; sweep a circle on the arms to lay the shrouds to, while fitting them; put a small draw-pin in the middle of each lap, to draw the joints close; strike true circles both for the inside and outside of the shrouds, and  $1\frac{1}{2}$  inches from the inside, where the arms are to be let in.

9. Divide the circle into 8 equal parts, coming as near the middle of each shroud as possible; strike a scribe across each to lay out the notch by, that is to be cut  $1\frac{1}{2}$  inches deep, to let in the arm at the bottom, where it is to be forked to take in the remainder of the shroud. Strike a scribe on the arms with the same sweep that the stroke for the notches on the shrouds was struck with.

10. Scribe square down on each side of the arms, at the bottom, where they are to be forked; make a gauge to fit the arms, so wide as just to take in the shrouds, and leave  $1\frac{1}{2}$  inches of wood outside of the mortise; bore 1 or 2 holes through each end of the arms to draw-pin the shrouds to the arms when hung; mark all the arms and shrouds to their places, and take them apart.

11. Fork the arms, put them together again, and put the shrouds into the arms; draw-bore them, but not too much, which would be worse than too little; take the shrouds apart again, turn them the other side up, and draw the joints together with the pins, and lay out the notches for 4 floats between each arm, 32 in all, large enough for admitting keys to keep them fast, but allowing them to drive in when any thing gets under the wheel. The ends of the floats must be dove-tailed a little into the shrouds; when one side is framed, frame the other to fellow it. This done, the wheel is ready to hang, but remember to face the shrouds between the arms

with inch boards, nailed on with strong nails, to keep the wheel firmly together.

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ARTICLE 130.

DIRECTIONS FOR DRESSING SHAFTS, &c.

The shaft for a water-wheel with 8 arms should be 16 square, or 16 sided, about 2 feet diameter, the tree to make it being 2 feet 3 inches at the top end. When cut down, saw it off square at each end, and roll it on level skids, and if it be not straight, lay the rounding side down and view it, to find the spot for the centre at each end. Set the large compasses to half its diameter, and sweep a circle at each end, plumb a line across each centre, and at each side of the circle, striking chalk lines over the plumb lines at each side from end to end, and dress the sides plumb to these lines; turn it down on one side, setting it level; plumb, line, and dress off the sides to a 4 square; set it exactly on one corner, and plumb, line, and dress off the corner to 8 square. In the same manner dress it to 16 square.

To cut it square off to its exact length, stick a peg in the centre of each end, take a long square, (which may be made of boards,) lay it along the corner, the short end against the end of the peg, mark on the square where the shaft is to be cut, and mark the shaft by it at every corner line, from mark to mark; then cut it off to the lines, and it will be truly square.

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ARTICLE 131.

TO LAY OUT THE MORTISES FOR THE ARMS.

Find the centre of the shaft at each end, and strike a circle; plumb a line through the centre at each end to be in the middle of two of the sides; make another scribe square across it; divide the distance equally between them, so as to divide the circle into 8 equal parts, and strike a line from each of them, from end to end, in the middle of the sides; measure from the top end about 3

feet, and mark for the arm of the water-wheel, and the width of the wheel, and make another mark. Take a straight-edged 10 feet pole, and put the end even with the end of the shaft, and mark on it even with the marks on the shaft, and by these marks measure for the arm at every corner, marking and lining all the way round. Then take the uppermost arms of each rim, and by them lay out the mortises, about half an inch longer than they are wide, which is to leave key room; set the compasses a little more than half the thickness of the arms, and set one foot in the centre line at the end of the mortise, striking a scribe each way to lay out the width by; this done, lay out 2 more on the opposite side, to complete the mortises through the shaft. Lay out 2 more, square across the first, one-quarter the width of the arm longer, inwards, towards the middle of the wheel. Take notice which way the locks of the arms wind, whether to right or left, and lay out the third mortises to suit, else it will be a chance whether they suit or not: these must be half the width of the arms longer, inwards.

The 4th set of mortises must be three-fourths longer inwards than the width of the arms; the mortises should be made rather hollowing than rounding, that the arms may slip in easily and stand fair.

If there be 3 (which are called 6) arms to the cog-wheel, but one of them can be put through the sides of the shaft fairly; therefore, to lay out the mortises, divide the end of the shaft anew, into but 6 equal parts, by striking a circle on each end; and without altering the compasses, step from one of the old lines, six steps round the circle, and from these points strike chalk lines, and they will be the middle of the mortises, which may be laid out as before, minding which way the arms lock, and making two of the mortises one-third longer than the width of the arm, extending one on one side, and the other on the other side of the middle arm.

If there be but 2 (called 4) arms in the cog-wheel, (which will do where the number of cogs does not exceed 60) they will pass fairly through the sides, whether the shafts be 12 or 16 sided. One of these must be made one-

half longer than the width of the arms, to give room to put the arm in.

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ARTICLE 132.

TO PUT IN THE GUDGEONS.

Strike a circle on the ends of the shaft to let on the end bands; make a circle all round,  $2\frac{1}{2}$  feet from each end, and saw a notch all round, half an inch deep. Lay out a square, round the centres, the size of the gudgeons, near the neck; lay the gudgeons straight on the shaft, and scribe round them for their mortises; let them down within one-eighth of an inch of being in the centre. Dress off the ends to suit the bands; make 3 keys of good, seasoned white oak, to fill each mortise above the gudgeons, to key them in, those next to the gudgeons to be  $3\frac{1}{4}$  inches deep at the inner end, and  $1\frac{1}{2}$  inches at their outer end, the wedge or driving key 3 inches at the head, and 6 inches longer than the mortise, that it may be cut off, if it batter in driving; the piece next the band so wide as to rise half an inch above the shaft, when all are laid in. Then take out all the keys and put on the bands, and make 8 or 12 iron wedges about 4 inches long by 2 wide,  $1\text{-}3\text{d}$  inch thick at the end, not much tapered except half an inch at the small end, on one side next the wood; by means of a set, drive them in on each side the gudgeon extremely hard, at a proper distance apart. Then put in the keys again, and lay a piece of iron under each band, between it and the key, 6 inches long, half an inch thick in the middle, and tapering off at the ends; then grease the keys well with tallow, and drive it well with a heavy sledge: after this, drive an iron wedge, half an inch from the two sides of each gudgeon, 5 inches long, about half an inch thick, and as wide as the gudgeon.

## ARTICLE 133.

## OF COG-WHEELS.

The great face cog-wheels require 3 (called 6) arms, if the number of cogs exceed 54; if less, 4 will do. We find by the table, example 43, that the cog-wheel must have 69 cogs, with  $4\frac{1}{2}$  inches pitch, the diameter of its pitch circle 8 feet  $2\frac{1}{3}$  inches, and of its outsides 8 feet  $10\frac{1}{3}$  inches. It requires 3 arms, 9 feet long, 14 by  $3\frac{3}{4}$  inches; 12 cants,  $6\frac{1}{2}$  feet long, 16 by 4 inches. (See it represented, fig. 1, Plate XVII.)

To frame it, dress and lock the arms together, (fig. 6, Pl. XVII.) as directed, Art. 129, only mind to leave one-third of each arm uncut, and to lock them the right way to suit the winding of the mortises in the shaft, which is best found by putting a strip of board in the middle mortise, and supposing it to be the arm, mark which way it should be cut, then apply the board to the arm, and mark it. The arms being laid on a truckle, as directed, Art. 129, make a sweep, the sides directing to the centre, 2 feet from the outer end to scribe by; measure on the sweep, half the diameter of the wheel; and by it circle out the back edges of the cants, all of one width in the middle; dress them, keeping the best faces for the face side of the wheel; make a circle on the arms half an inch larger than the diameter of the wheel, laying 3 of the cants with their ends on the arms, at this circle, at equal distances apart. Lay the other three on the top of them, so as to lap equally; scribe them both under and top, and gauge all for the laps from the face side; dress them out and lay them together, and joint them close; draw-pin them by an inch pin near their inside corners: this makes one-half of the wheel, shown fig. 5. Raise the centre level with that half; strike a circle near the outside, and find the centre of one of the cants; then, with the sweep that described the circle, step on the circle 6 steps, beginning at the middle of the cant, and these steps will show the middle of all the cants, or places for the arms. Make a scribe from the centre across each; strike another circle exactly at the corners, to place the corners of the

next half by, and another about  $2\frac{1}{2}$  inches farther out than the inside of the widest part of the cant, to let the arms in by; lay on three of the upper cants, the widest part over the narrowest part of the lower half, the inside to be at the point where the corner circle crosses the centre lines. Saw off the ends, at the centre scribes, and fit them down to their places, doing the same with the rest. Lay them all on, and joint their ends together; draw-pin them to the lower half, by inch pins, 2 inches from their inner edges, and 9 inches from their ends. Raise the centre level with the wheel; plane a little of the rough off the face, and strike the pitch circle, and another 4 inches inside, for the width of the face; strike another very near it, in which drive a chisel, half an inch deep, all round, and strike lines, with chalk, in the middle of the edge of the upper cants, and cut out of the solid, half of the upper cants, which raises the face; divide the pitch circle into 69 equal parts,  $4\frac{1}{2}$  inches pitch, beginning and ending in a joint; strike two other circles each  $2\frac{1}{2}$  inches from the pitch circle, and strike central scribes between the cogs, and where they cross the circles put in pins, as many as there are cogs, half on each circle; find the lowest part on the face, and make the centre level with it; look across in another place, square with the first, and make it level with the centre also; then make the face straight, from these four places, and it will be true.

Strike the pitch circle, and divide it over again, and strike one circle on each side of it, 1 inch distance, for the cog mortises; sweep the outside of the wheel and inside of the face, and two circles  $\frac{3}{4}$ ths of an inch from them, to dress off the corners; strike a circle of two inches diameter on the centre of each cog, and with the sweep strike central scribes at each side of these circles for the cog mortises; bore and mortise half through; turn the wheel, dress and mortise the back side, leaving the arms from under it; strike a circle on the face edge of the arms, equal in diameter to that struck on the face of the half wheel, to let them in by; saw in square, and take out  $4\frac{1}{2}$  inches, and let them into the back of the wheel  $1\frac{1}{4}$  inches deep, and bore a hole  $1\frac{1}{2}$  inches into each arm, to pin it to the wheel.

Strike a circle on the arms one inch less than the diameter of the shaft; make a key 8 inches long,  $1\frac{1}{2}$  thick,  $3\frac{1}{4}$  at the butt, and  $2\frac{1}{2}$  inches at the top end, and by it lay out the mortises; two on each side of the shaft, in each arm, to hang the wheel by.

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ARTICLE 134.

OF SILLS, SPUR-BLOCKS, AND HEAD-BLOCKS.

See a side view of them in Plates XIII., XIV., XV., and XVI., and a top view of them, with their keys, at the end of the shaft, Plate XVIII. The sills are generally 12 inches square. Lay them on the wall as firmly as possible, and one 3 feet farther out; on these lay the spurs, which are 5 feet long, 7 by 7 inches, 3 feet apart, notched and pinned to the sills: on these are set the head-blocks, 14 by 12 inches, 5 feet long, let down with a dove-tail shoulder between the spurs, to support keys to move it endwise, and let 2 inches into the spurs with room for keys, to move it sidewise, and hold it to its place; see fig. 33 and 34, Plate XVIII. The ends of the shaft are let 2 inches into the head-blocks, to throw the weight more on the centre.

Provide two stones 5 or 6 inches square, very hard and clear of grit, for the gudgeons to run on, let them into the head-blocks, put the cog-wheel into its place, and then put in the shaft on the head-blocks in its place.

Put in the cog-wheel arm, lock them together, and pin the wheel to them; then hang the wheel, first by the keys to make it truly round, and then by side wedges, to make it true in face; turn the wheel, and make two circles, one on each side of the cog mortises, half an inch from them, so that the head of the cogs may stand between them equally.



## ARTICLE 135.

## OF COGS; THE BEST TIME FOR CUTTING, AND MANNER OF SEASONING THEM.

Cogs should be cut 14 inches long, and  $3\frac{1}{4}$  inches square; this should be done when the sap runs at its fullest, at least a year before they are used, that they may dry without cracking. If either hickory or white oak be cut when the bark is set, they will worm-eat, and, if dried hastily, will crack; to prevent which, boil them and dry them slowly, or soak them in water, a year, (20 years in mud and fresh water would not hurt them;) when they are taken out they should be put in a hay-mow, under the hay, where, while foddered away, they will dry without cracking; but this often takes too long a time. I have discovered the following method of drying them, in a few days, without cracking. I have a malt kiln with a floor of laths two inches apart; I shank the cogs, hang them shank downwards, between the laths, cover them with a hair cloth, make a wood fire, and the smoke prevents them from cracking. Some dry them in an oven, which ruins them. Boards, planks, or scantling, are best dried in a kiln, covered so as to keep the smoke amongst them. Instead of a malt kiln, dig a cave in the side of a hill, 6 feet deep, 5 or 6 feet wide, with a post in each corner with plates on them, on which lay laths on edge, and pile the cogs on end, nearly perpendicular, so that the smoke can pass freely through, or amongst them. Cover them slightly with boards and earth, make a slow fire, and close up the sides, and renew the fire once a day, for 12 or 15 days they will then dry without cracking.

## ARTICLE 136.

## OF SHANKING, PUTTING IN, AND DRESSING OFF COGS.

Straighten one of the heart sides for the shank, make a pattern, the head 4 and shank 10 inches long, and 2 inches wide at the head,  $1\frac{3}{4}$  at the point; lay it on the cog, scribe the shank and shoulders, for the head, saw in

and dress off the sides; make another pattern of the shank, without the head, to scribe the sides and dress off the backs by, laying it even with the face, which is to have no shoulder; take care in dressing them off, that the axe do not strike the shoulder; if it do, it will crack there in drying, (if they be green;) fit and drive them in the mortises exceedingly tight, with their shoulders foremost, when at work. When the cogs are all in, fix two pieces of scantling, for rests, to scribe the cogs by, one across the cog-pit, near the cogs, another in front of them; fix them firmly. Hold a pointed tool on the rest, and scribe for the length of the cogs, by turning the wheel, and saw them off  $3\frac{1}{2}$  inches long; then move the rest close to them, and fix it firmly; find the pitch circle on the end of the cogs, and, by turning the wheel, describe it there.

Describe another line  $\frac{1}{4}$ th of an inch outside thereof, to set the compasses in to describe the face of the cogs by, and another at each side of the cogs to dress them to their width; then pitch the cogs by dividing them equally, so that, in stepping round, the compasses may end in the point where they began; describe a circle, in some particular place, with the pitch, that it may not be lost; these points must be as nearly as possible of a proper distance for the centre from the back of the cogs; find the cog to the back of which this point comes nearest, and set the compasses from that point to the back of the cog; with this distance set off the backs of all the cogs equally, on the circle,  $\frac{1}{4}$ th of an inch outside of the pitch circle, and from these points, last made, set off the thickness of the cogs, which should, in this case, be  $1\frac{1}{8}$  inches.

Then describe the face and back of the cogs by setting the compasses in the hindmost point of one cog, and sweeping over the foremost point of another, for the face, and in the foremost point of one, sweeping over the hindmost of the other, for the back part; dress them off on all sides, tapering about  $\frac{1}{8}$ th of an inch, in an inch distance; try them by a gauge, to make them all alike; take a little off the corners, and they are finished.