Given, the depth 24 inches; required, the sides to hold 6,56 bushels.

Then, 6,56 multiplied by 2150,4 equal to 14107,624; which, divided by 8, gives 1764, the square root of which is 42 inches; which is the length of the sides of the hopper wanted.

CHAPTER VI.

ARTICLE 78.

OF THE DIFFERENT KINDS OF GEARS, AND FORMS OF COGS.

In order to conceive a just idea of the most suitable form or shape of cogs in cog-wheels, we must consider that they describe, with respect to the pitch circles, a figure called an Epicycloid.

And when one wheel works in cogs set in a straight line, such as the carriage of a saw-mill, the cogs or rounds, moving out and in, form a curve called a Cycloid.

To describe this figure, let us suppose the large circle in Plate V, fig. 37, to move on the straight line from O to A; then the point O, in its periphery, will describe the arch ODA, which is called a Cycloid; and by the way in which the curve joins the line, we may conceive what should be the form of the point of the cog.

Again, suppose the small circle to run round the large one; then the point o, in the small circle, will describe the arch O b C, called an Epicycloid; by which we may conceive what should be the form of the point of the cogs. But, in common practice, we generally let the cogs extend but a short distance past the pitch circle; so that their precise form is not so important.

ARTICLE 79.

OF SPUR GEARS.

The principle of spur gears, is that of two cylinders rolling on each other, with their shafts or axes truly pa-

rallel. Here the touching parts move with equal velocity, and have, therefore, but little friction; but to prevent these cylinders from slipping, we are obliged to indent, or to set cogs in, them.

It appears to me that, in this kind of gear, the pitch of the driving wheel should be a little larger than that of the leading wheel, for the following reasons:—

1. If there is to be any slipping, it will be much easier for the driver to slip a little past the leader, than for the cogs to have to force the leader a little before the driver; which would be very hard on them.

2. If the cogs should bend any, by the stress of the work, as they assuredly do, this will cause those that are coming into gear to touch too soon, and rub hard at entering.

3. It is much better for cogs to rub hard as they are going out of gear, than as they are coming in; because then they work with the grain of the wood; whereas, at entering they work against it, and would wear much faster.

The advantage of this kind of gear is, that we can make the cogs as wide as we please, so that their bearing may be so large that they will not cut, but only polish each other, and wear smooth; therefore, they will last a long time.

Their disadvantages are,

1st. That if the wheels be of different sizes, and the pitch circles are not made to meet exactly, they will not run smoothly. And,

2dly. We cannot, conveniently, change the direction of the shafts.

Fig. 38, Plate V. shows two spur wheels working into each other; the dotted lines show the pitch circles, which must always meet exactly. The ends of the cogs are made circular, as is commonly done; but, if they were made true epicycloids, adapted to the size of the wheels, they would work with less friction, and, consequently, be much better.

Fig. 39, is a spur and face wheel, or wallower, whose pitch circles should always meet exactly.

The rule for describing the sides of the cogs, so as nearly to approach the figure of an epicycloid, is as follows; namely: Describe a circle a little inside of the pitch circle, for the point of your compasses to be set in, so as to describe the sides of the cogs, (as the four cogs at A, Plate V. fig. 38—39,) as near as you can to the curve of the epicycloid that is formed by the little wheel moving round the great one; the greater the difference between the great and small wheels, the greater distance must this circle be within the pitch circle: in doing this properly, much will depend upon the judgment of the workman.*

ARTICLE 80.

OF FACE GEARS.

The principle of face gears, is that of two cylinders rolling with the side of one on the end of the other, their axes being at right angles. Here, the greater the

* The following is Mr. Charles Taylor's rule for ascertaining the true cycloidical or epicycloidical form for the point of cogs:—

Make a segment of the pitch circle of each wheel, which gear into each other; fasten one to a plain surface, and roll the other round it as shown, Plate V. fig. 37, and, with a point in the moveable segment, describe the epicycloid o b c; set off at the end o one-fourth part of the pitch for the length of the cog outside of the pitch circle. Then fix the compasses at such an opening, that with one leg thereof, in a certain point, (to be found by repeated trials,) the other leg will trace the epicycloid from the pitch circle to the end of the cog: preserve the set of the compasses, and through the point where the fixed leg stood, sweep a circle from the centre of the wheel, in which set one point of the compasses to describe the point of all the cogs of that wheel whose segment was made fast to the plane.

If the wheels be bevel gear, this rule may be used to find the true form of both the outer and inner ends of the cogs, especially if the cogs be long, as the epicycloid is different in different circles. In making cast-iron wheels, it is absolutely necessary to attend to forming the cogs to the true epicycloidical figure, without which they will grind and wear rapidly.

The same rule serves for ascertaining the cycloidical form of a right line of cogs, such as those of a saw-mill carriage, &c., or of cogs set inside of a circle or hollow cone. Where a wheel works within a wheel, the cogs require a very different shape.

bearing, and the less the diameter of the wheels, the greater will be the friction; because the touching parts move with different velocities—therefore, the friction will be great.

The advantages of this kind of gear are,

1st. Their cogs stand parallel to each other; therefore, moving them a little out of or in gear, does not alter the pitch of the bearing parts of the cogs, and they will run smoother than spur gears, when their centres are out of place.

2dly. They serve for changing the direction of the shafts.

Their disadvantages are,

1st. The smallness of the bearing, so that they wear out very fast.*

2dly. Their great friction and rubbing of parts.

The cogs for small wheels are generally round, and put in with round shanks. Great care should be taken in boring the holes for the cogs, with a machine, to direct the auger straight, that the distance of the cogs may be equal, without dressing. And all the holes of all the small wheels in a mill should be bored with one auger, and made of one pitch; then the miller may keep by him a quantity of cogs ready turned to a gauge, to suit the auger; and, when any fail, he can put in new ones, without much loss of time.

Fig. 40, Plate V. represents a face cog-wheel working into a trundle; showing the necessity of having the corners of the sides of the cogs sniped, or worked, off in a cycloidal form, to give liberty for the rounds to enter between the cogs, and pass out again freely. To describe the sides of the cogs of the right shape to meet the rounds when they get fairly into gear, as at c, there must be a circle described on the ends of the cogs, a little outside of the pitch circle, for the point of the compasses to be set in, to scribe the ends of the cogs; for, if the point be set in the pitch circle, it will leave the inner

* If the bearing of the cogs be small, and the stress so great that they cut one another, they will wear exceedingly fast; but if it be so large, and the stress so light, that they only polish one another, they will last very long.

corners too full, and make the outer ones too scant. The middle of the cog is to be left straight, or nearly so, from bottom to top, and the side nearly flat, at the distance of half the diameter of the round, from the end, the corners only being worked off to make the ends of the shape in the figure; because, when the cog comes fully into gear, as at c, the chief stress is there, and there the bearing should be as large as possible. The smaller the cog-wheel, the larger the trundle, and the wider the cogs, the more will the corners require to be worked off. Suppose the cog-wheel to turn from 40 to b, the cog 40, as it enters, will bear on the lower corner, unless it be sufficiently worked off; when it comes to c, it will be fully in gear, and if the pitch of the cog-wheel be a little larger than that of the trundle, the cog a will bear as it goes out, and let c fairly enter before it begins to bear.

Suppose the plumb line A B to hang directly to the centre of the cog-wheel, the spindle is, by many millwrights, set a little before the line or centre, that the working round, or stave, of the trundle may be fair with said line, and meet the cog fairly as it comes to bear; by this means, also, the cogs enter with less, and go out with more friction. Whether there be any real advantage in thus setting the spindle foot before the centre plumb line, does not seem to be determined.

ARTICLE 81.

OF BEVEL GEARS.

The principle of bevel gears, is that of two cones rolling on the surface of each other, their vertexes meeting in a point, as at A, fig. 41, Plate V. Here the touching surfaces move with equal velocities in every part of the cones; therefore, there is but little friction. These cones, when indented, or fluted, with teeth diverging from the vertex to the base, to prevent them from slipping, become bevel gear; and as these teeth are very small at the

point or vertex of the cone, they may be cut off 2 or 3 inches from the base, as 19 and 25, at B; they then have the appearance of wheels.e

To make these wheels of a suitable size for any number of cogs you choose to have to work into one another, take the following

RULE.

Draw lines to represent your shafts, in their proper direction, with respect to each other, to intersect A; then take from any scale of equal parts, as feet, inches, or quarters, as many parts as your wheels are to have cogs, and at that distance from the respective shafts, draw the dotted lines a, h, c, d, for 21 and 20 cogs; and from where they cross at e, draw e A. On this line, which makes the right bevel, the pitch circles of the wheels will meet, to contain that proportion of cogs of any pitch.

Then, to determine the size of the wheels to suit any particular pitch, take from the table of pitch circles, the radius in measures of the pitch, and apply it to the centre of the shaft, and the bevel line A e, taking the distance at right angles with the shaft; and it will show the point in which the pitch circles will meet, to suit that particular pitch.

By the same rule, the sizes of the wheels at B and C are found.

Wheels of this kind, when made of cast iron, answer exceedingly well.

The advantages of this kind of gear are,

1. They have very little friction, or sliding of parts.

2. We can make the cogs of any width of bearing we choose; therefore, they will wear a great while.

3. By them we can set the shafts in any direction desired, to produce the necessary movements.

Their disadvantage is,

They require to be kept exactly of the right depth in gear, so that the pitch circles meet constantly, else they will not run smooth, as is the case with spur gears.

The universal joint, as represented fig. 43, may be

applied to communicate motion, instead of bevel gear, where the motion is to be the same, and the angle not more than 30 or 40 degrees. This joint may be constructed by a cross, as in the figure, or by four pins, fastened at right angles on the circumference of a hoop or solid ball. It may sometimes serve to communicate the motion, instead of two or three face wheels. The pivots, at the end of the cross, play in the ends of the semicircles. It is best to screw the semicircles to the blades, that they may be taken apart.

ARTICLE 82.

OF MATCHING WHEELS TO MAKE THE COGS WEAR EVEN.

Great care should be taken in matching or coupling the wheels of a mill, that their number of cogs not be such that the same cogs will often meet; because, if two soft ones meet often, they will both wear away faster than the rest, and destroy the regularity of the pitch; whereas, if they are continually changing, they will wear regular, even if they be, at first, a little irregular.

For finding how often wheels will revolve before the same cogs meet again, take the following

RULE.

1. Divide the cogs in the greater wheel by the cogs in the lesser; and if there be no remainder, the same cogs will meet once every revolution of the great wheel.

2. If there be a remainder, divide the cogs in the lesser wheel by the said remainder; and if it divide them equally, the quotient shows how often the great wheel will revolve before the same cogs meet.

3. But if it will not divide equally, then the great wheel will revolve as often as there are cogs in the small wheel, and the small wheel as often as there are cogs in the large wheel, before the same cogs meet:

they never can be made to change more frequently than this.

EXAMPLE.

Given, wheels of 13 and 17 cogs; required, how often each will revolve before the same cogs meet again.

```
Then 13)17(1
        13
        —
         4)13(3
           12      Answer,
           —       Great wheel 13, and
            1      Small wheel 17 revolutions.
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ARTICLE 83.

THEORY OF ROLLING SCREENS AND FANS, FOR SCREENING AND FANNING THE WHEAT IN MILLS.

Let fig. 42, Plate V. represent a rolling screen and fan, fixed for cleaning wheat in a merchant-mill. DA the screen, AF the fan, AB the wind tube, 3 feet deep from a to b, and 4 inches wide, in order that the grain may have a good distance to fall through the wind, to give time and opportunity for the light parts to be carried forward, away from the heavy parts. Suppose the tube to be of equal depth and width for the whole of its length, except where it communicates with the tight boxes or garners under it; namely: C for the clean wheat, S for the screenings and light wheat, and c for the cheat, chaff, &c. Now, it is evident, that if wind be driven into the tube at A, and if it can no where escape, it will pass on to B, with the same force as at A, let the tube be of any length or direction; and any thing which it will move at A, it will carry out at B, if the tube be of an equal size all the way.

It is also evident, that if we shut the holes of the fan at A and F, and let no wind into it, none can be forced into the tube; hence, the best way to regulate the blast

is, to fix shutters sliding at the air holes, to give more or less feed, or air, to the fan, so as to produce a blast sufficient to clean the grain.

The grain enters, in a small stream, into the screen at D, where it passes into the inner cylinder. The screen consists of two cylinders of sieve wire; the inmost one has the meshes so open as to pass all the wheat through it to the outer one, retaining only the white caps, large garlic, and every thing larger than the grain of the wheat, which falls out at the tail A.

The outer cylinder is so close in the meshes, as to retain all good wheat, but to sift out the cheat, cockle, small wheat, garlic, and every thing less than good grains of wheat; the wheat is delivered out at the tail of the outer cylinder, which is not quite as long as the inner one, whence it drops into the wind tube at a; and as it falls from a to b, the wind carries off every thing lighter than good wheat; namely: cheat, chaff, light garlic, dust, and light, rotten grains of wheat; but, in order to effect this completely, it should fall, at least, 3 feet through the current of wind.

The clean wheat falls into the funnel b, and thence into the garner C, over the stones. The light wheat, screenings, &c. fall into garner S, and the chaff settles into the chaff room c. The current slackens in passing over this room, and drops the chaff, but resumes its full force as soon as it is over, and carries out the dust through the wall at B. To prevent the current from slackening too much, as it passes over S and c, and under the screen, make the passages, where the grain comes in and goes out, as small as possible, not more than half an inch wide, and as long as necessary. If the wind escapes any where but at B, it defeats the object, and carries the dust into the mill. Valves may be fixed to shut the passages by a weight or spring, so that the weight of the wheat, falling on them, will open them just enough to let it pass, without suffering any wind to escape.

The fan is to be so set as to blow both the wheat and screenings, and carry out the dust. It is to be recol-