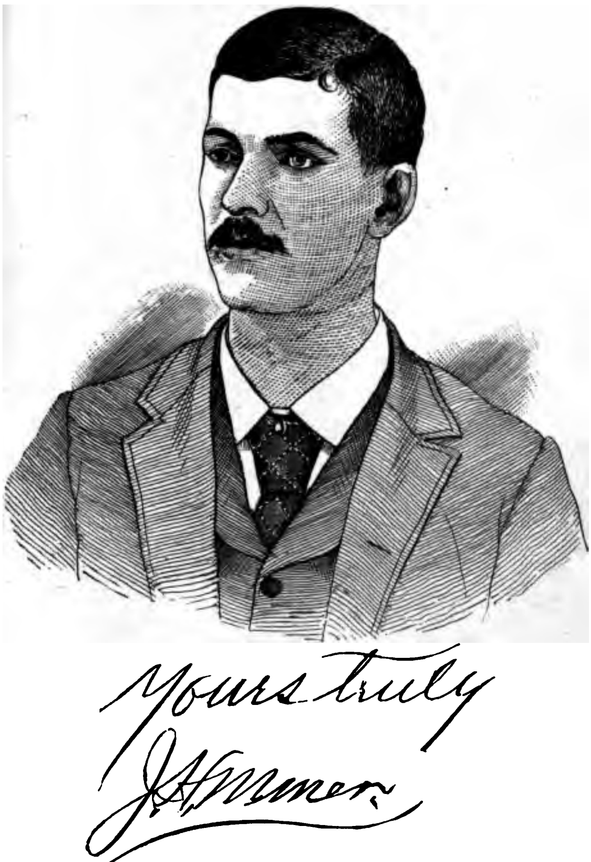

Yours truly

The Mill and Lumberman's Success.

A TREATISE

ON THE CARE OF ALL KINDS OF SAWS. FULLY ILLUSTRATED FOR EVERY VARIETY OF WORK AND CLASS OF TIMBER.

HOW TO BE A SUCCESSFUL SAW AND PLANER MAN, MILL BUILDING, ETC.

QUARTER SAWING AND THE SAWING OF VALUABLE TIMBER TO ADVANTAGE. STACKING AND HOW TO TAKE CARE OF LUMBER.

LIGHTNING LUMBER CALCULATIONS. STANDARD LOG AND OTHER RULES. CARE OF BELTING AND GENERAL SAW MILL MACHINERY, MECHANICAL RECEIPTS, ETC.

BY
J. H. MINER,
Baton Rouge, La.

PREFACE.

In entering this, my second edition on saws, I shall not only treat more fully on hammering, but on the care and management of all kinds of saws. This contains no history of saws, but the saw of to-day just as every user wants. Practical millmen know that a saw fitted up for a certain kind of wood, feed and speed will by no means run at a *vice versa* from this.

In this work I shall show by illustrations, saws adapted for every purpose. How to hammer, grind and sharpen for hard, soft and frozen timber.

There is acknowledged to be a less standard among millmen than any other business. Most everyone has his peculiar way. This is true, especially with filers, and not one out of ten can take right hold of a mill of a double or triple capacity and go right ahead, simply because he is clinging to the style of tooth condition of saw that suited A's mill while B's mill wants an entirely different tooth, etc. I shall illustrate this fully, and arranged in parts so that the reader may readily apply his case. One-half of our present mills would cut 25 per cent. more and better lumber if their saw was in proper order. This is saying nothing about the condition of machinery, &c. This work will put a man right there, and will prove of inestimable value to all who thoroughly apply it.

My treatment on band saws will be found to comprise all there is toward making a perfect saw, treating fully on proper shaped teeth, how to hammer fully, and the general care of such saws. This is from the very best authority and builders in the United States, and can be wholly relied on. This work will be of interest to saw and planing mill builders, treating on the most convenient plans illustrated, how to care for planers and wood-working machinery, together with valuable rules and suggestions about sawing choice lumber, lightning calculations not found in any other publication. Shingle saws are treated fully. My instructions on same will save a man hundreds of dollars annually. These will be proven as facts by simply following instructions.

J. H. MINER.

SPECIAL NOTICE.

This work is compiled with the view of applying itself readily to all millmen and lumbermen, ranging from the amateur beginner to the expert. This work is arranged in parts, one to three, in hammering, filing and gumming, so that the reader can readily apply himself. There are many works out, not from a practical basis, that are of no value. All that is asked is a careful study and application.

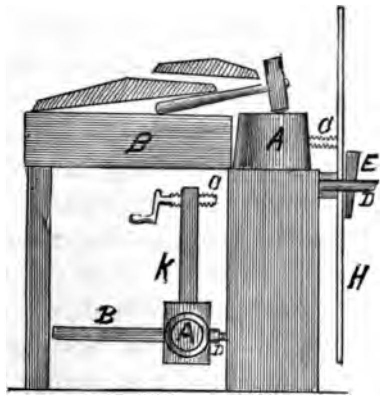
HAMMERING CIRCULAR SAWS.

FOR BEGINNERS, SHOWING HOW TO STRAIGHTEN SAWS.

PART I.

This first lesson I shall confine myself to such treatment as is best adapted to beginners, and as he advances, the nearer the perfect saw will be reached. The first requisite is tools. No man can do anything without tools. A good workman with poor tools can scarcely accomplish anything.

The accompanying engraving represents a cheap, handy sawbench which ought to be in every mill. While it is not all that might be desired as a man advances, it is certainly what is necessary for a beginner. The tools shown in cut are worth about $10.00. The anvil *A* is set on an end of a 12x12 block, with a mortise to receive pin *D*, which has a shoulder and reduced to 2″, just the size of hole in your saw. This pin is cut at a slant directly at *D*, which allows the operator to tilt or cant the saw in a horizontal position on anvil for hammering. *E* shows a key for tightening saw *H*. *B* shows support for saw level with face of



anvil. *K* shows an L attached to the anvil post at right angle. *C* shows a screw which is run behind the anvil. This screw is foı a support by which a dished saw may be sprung straight before applying the straightedge. This is necessary, as any saw dished if but a little, forms a part of sphere and is full or high under the straightedge whereever it is applied. Now, it is very evident that the saw is not sprung all over as it appears, although four-fifths of the hammerers of to-day will begin on such a saw by pounding all over or on straight segment lines from center to rim, all of which makes a saw worse. By adding up all the good men, a fair conception can be drawn from the number that is left. The first thing is to get the saw in as near a straight position as possible, then apply the straightedge and it will tell the truth. As I will treat briefly and very plainly here, a beginner can easily understand.

All saws that require hammering badly are generally dished from the log, often caused by blue spots or "bull's eyes." These places are caused by excessive heat, and in one term are a blister. If the stain of the blue yet remains on saw, it can be located, and will show a very high place on the log side. Hang saw on bench full side out and set out screw *C* to saw. Then with the left hand spring saw until it appears straight, then apply say 20″ straightedge in perpendicular position with right hand, letting it extend down to collar. I will add here that key *E* may put in a horizontal position, instead as in cut. This will allow straightedge to come down below the bearing of the collars and will plainly show defects. A good, open light (North or East) is best, with no dark object in front of you. Mark with a piece of chalk or hard bar soap all the highest places, holding the straightedge perpendicular. After going around the saw, take the straightedge and apply it at right angles on all the marks you have made, that is, directly across the former way. Now if in this position you find any places that do not show a lump, rub out the cross mark and make a long mark in the direction of the straightest way of the saw. This shows a twisted place, that is, sprung more one way than the other. Now take the straightedge and apply it on the rim in a horizontal position (level) as close as possible. In this position you will find several high places, showing to be higher directly on the extreme

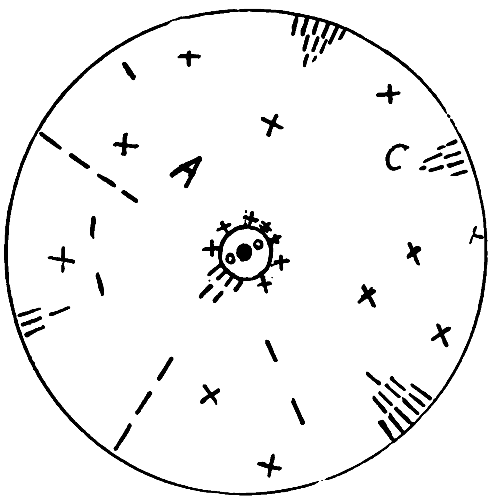


Fig. 1.

edge; for such places two or three straight parallel marks are made, as shown at *C*, Fig. 1, the marks gradually diminishing at from 4″ to from the rim, as to the height of the twist. I 1 shows about how the saw will appear after be carefully tested with the straightedge. A serie: marks are shown just outside of the collar. T is where the saw was sprung from being dish All dished saws are sprung near the collar, unl they have one or more blue spots as shown at Fig. 2.

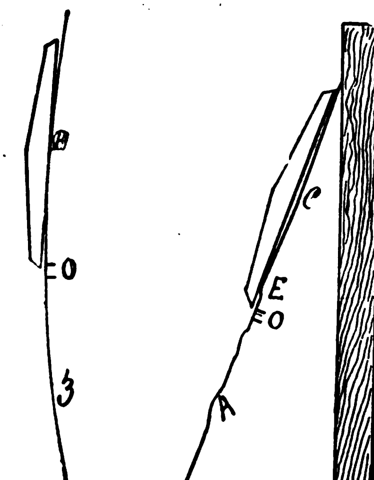


Fig 2.

It will be necessary here to say a little m about a dished saw. If a saw is dished and sh one or two blue spots in testing, often the removal of such places will practically straighten the saw. Fig. 2 shows the appearance of a dished saw. Fig. 3 shows the saw standing erect with straightedge applied. At *B* it shows considerable high places; in fact, the straightedge will show a high place in any position. *E* shows the saw leaned as stated until it appears straight to the sighting of the eye, (this is accomplished with screw *C* on the bench). The straightedge shows a low place at *C* where it formerly showed a very high place. *E* shows it

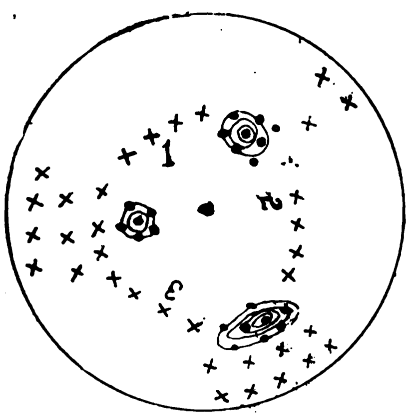


Fig. 3.

sprung just outside of the collars, the marks in Fig. 1 showing how it is laid off for straightening. *A* shows considerable of a lump. This is a blue spot.

Often the removal of such places where there are three of them, as in Fig. 3, will bring a dished saw, as stated, nearly straight. So it is plainly seen the necessity of getting the saw in the proper position before applying the straightedge. (Many a man has failed right here.)

The saw Fig. 1 is laid on the leather pad or piece of pasteboard applied on the face of the anvil, and may be secured by flaps extending down on each side with a band over them; this keeps it in place. Now with a helper strike a blow on each mark with the round peine, raising the hammer, say 18″ high, using a little exertion. If a thick saw, a little heavier blow; if a thin one, the weight of the hammer will almost do. Use the long peine on the long marks and *never* across them; places that are very high require often two or a half dozen blows, as the case of a blue spot. After you have worked all the marks, stand the saw on edge, bring it to a poise, and notice if it appears yet full on this side. If so, hang it back on the bench in the same position and examine the places that showed to be the highest. They may appear almost as high as ever, while the remainder of the spots may be fairly level. Lay saw on pad again and apply the same number of blows on such places. Saw may now set a little the other way, that is, dish a little to you. If so, this is all right, as you will find high places on the other side to bring it back. Reverse saw, but don't rub out the marks. After marking all the high places you find on this side, notice if any of the marks correspond with those that you have just worked on, if so, you have hit too heavy a blow. This is the best way to govern the weight of your blows. Nine-tenths of the saw hammerers strike too heavy, which eventually ruins a saw. Continue on both sides of the saw, being careful to bring all the twisted parts on the rim down level. If saw is dished and is high outside of collar, as shown in Fig. 2, *E*, don't strike too heavy; have the saw as solid on pad as possible and strike several blows in one place and much lighter; the reason of this is, some men have no judgment about pounding, and too much rebound—not solid—blows are liable to produce fracture, especially in a saw that has been badly dished several times. Some saws are made harder in center, hence the caution to prevent fracture. Treat the saw, say twice on each side, leaving it leaning a trifle to the log when standing erect on its edge or free on bench. Your saw may not screw up true on the mandrel. If not, it will invariably dish from the log, which indicates that saw or collar is wrong. Take the saw off and examine if you can't find a few small lumps near the collar, as shown in Fig. 1, and at *E*, Fig. 2;

if so, remove them on the pad, noticing carefully if they are a round or a long place. This you can easily locate with the 12″ straightedge applied at right angles. Such places invariably run from center to rim and from rim to center, as shown by the long marks in Fig. 1. After removing such places saw may dish too much toward the log; turn it around and examine between center and rim and you can easily find two or three high places, remove them, then your saw should screw up right; if not, it is in the collar, which you can either paper or turn off true, as treated further on. Your saw may now be much truer but not running much better. If it heats easily on the rim and has to be run warm in the center, that is, out of the log, it requires tensioning, which is fully treated in Part II. It is sometimes necessary to tension a saw the first thing. It is no common thing to find saws too long on the rim, the rim being slack, caused by heating and gumming. Now, if before you attempt the treatment I have just given, your saw should appear winding or twisting on the rim to your eye, it is a sure indication of needing tension. Again, a saw will often appear weak and loose on the rim, the rim quivering easily while the center does not, and by standing saw on edge and giving it a light shake, the rim will quiver and center remain very near still; again, pull the center toward you if it don't spring much at the center, and the rim bag back and forth, often springing the opposite way, is a sure indication. Again, if a saw appears a little winding and changes its position when rolled on its edge occasionally, a kind of jerk or quiver is noticed, which is another indication. If a doubtful case, and saw don't straighten easily, but seems very firm and all at once changes its position all over is a sure indication. Be careful to study this thoroughly. It is the best plan to open the saw on the anvil as treated in Part II. Saws that require tensioning are often run so long that they will assume a complete wind. Such a saw will require to be heated up in center by friction, or spoil one or two logs in getting saw straight, as sawyers call it, saying then, saw was all right.

Continuous use will put the best saw ever made in this shape, no matter how careful the sawyer is. Some cases have been two years with thick saws while others will not run two months on a small mill. This difference I will treat further on. Often a dished saw, after being straightened, will appear flimsy on the rim and discourage the operator. Remember that the center of saw must appear and be a little looser than the rim.

TENSIONING CIRCULAR SAWS.

PART II.

Tensioning saws is that part of treatment that necessitates stretching the metal. This is done on the anvil. The condition of all circular saws is that the metal must be equally strained or stretched. All saws naturally get slack on the rim that is longer, the metal expanding from heat gumming and the action of centrifugal force as stated. In all such cases the metal nearer the center must be stretched, which makes it as large as the rim, to use a common term. Often the center must be much larger than the rim, so that the saw dishes or sags back and forth at the center. This is in the case of high speeded saws.

Fig. 3 shows how to lay off such a saw, which was described in the clause of Part I. This cut shows five lines drawn, which is done by striking circles while saw is centered on the bench. A saw will often require but three or four lines. Now take the saw to the anvil, begin at the line nearest the center and apply blows about 2″ apart directly on the line, having saw bedded very firm on anvil, so that the blow will be solid. The best plan in changing positions of saw is to tap the saw lightly before applying the blow. If your saw is very stiff it may require hammering on four lines, then turn the saw around. Now, if your saw is not rusty you can see a dull spot where each blow

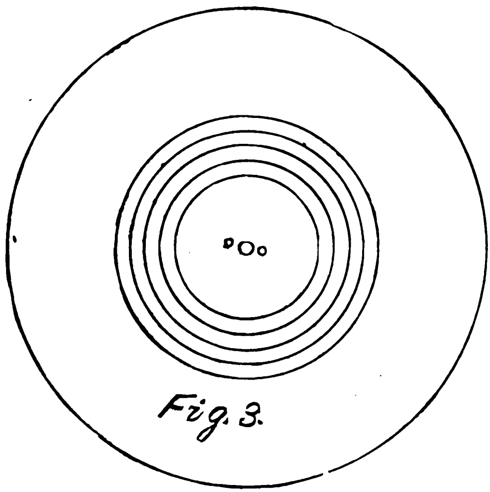


Fig. 3.

A STIFF SAW.

was applied. Strike a blow directly on each spot, the same blows on this side but not quite as heavy. When operating on such a saw, it will often appear as though it was getting worse, that is, where a saw is so badly stretched on the rim as to form a twist and appear firmer, not so limber, and when passing from this stiff, twisted state it appears quite limber and flimsy on the rim, but a continuation of the blows soon removes this. The case is often such before stretching the saw, that is, where saws are just slack enough to not quite twist and yet are sensitive and limber on the rim. This kind of a saw is not as slack as the one just described. I deem this explanation necessary, as I have had saws myself that almost seemed to be taking a backset, but soon came up. In this treatment, Part II, I will not go into as much detail about speed. If your saw is stiff and you open it until it shows to spring a little with the hand it will run 50 per cent. better than before. After opening up the saw until the center is a trifle the limberest, you can level up (straighten) as described in Part I, on block or pad.

Fig. 4 shows a dished saw. This may be described in two ways. A saw too open for its speed will dish back and forth the same both ways. Another form of dished saw is a new saw ordered hammered for too high a speed. Saw may not dish when screwed up on the mandrel, but a few days run discloses the fact that the saw leans from the log—is full on the log side. A description of the latter is this: It will lean but one way. Often if the saw is leaned to an angle of 45° the center will drop through the other way. The marks near the center of Fig. 4 at *B* show where it is sprung, which is just outside of the collars, as shown in Fig. 2 at *E*, but not quite so close to the collar, that is, not an abrupt place. It will show light lumps often 6″ from the collar. Straighten

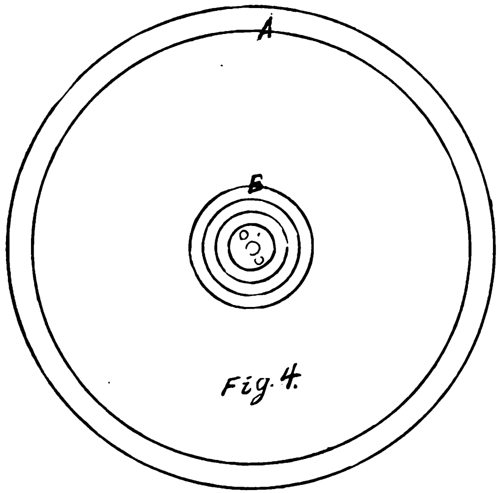


Fig. 4.—A DISHED SAW.

this place on the pad and where saw is brought true strike a line at *A* and go to the anvil and stretch this part, striking very light with blows about 4″ apart. It is a very easy matter to do too much of this, as the rim is many times larger than the center. In all cases of tensioning as described so far, is done regardless of lumps with the round peine of the hammer. It is not always necessary to stiffen a dished saw after straightening up. The description just given is on a new saw too open and dished, with but little use. Line *A* is to be applied to a saw that heats in the center and sags back and forth equally both ways, runs in and out of the cut, mostly out. Again, a saw that is dished and does not require stiffening, as line *A*, is invariably much harder to get back to its place, while a saw that is too open in the center often requires only a few light blows. This is the case with high speeded saws, it taking but very little to change them back and forth; but a stiff saw requires much more work.

It is hardly necessary to describe the many fogy ways that there are for treating a saw. Will say that many men attempt to hammer saws directly to the reverse. My system has met with such unprecedented success that I deem it not necessary to enter into a volume on the many fogy ways of hammering.

TENSIONING CIRCULAR SAWS TO SPEED FOR THE AVERAGE MILL.

It is an impossibility to adopt a speed suitable for all the variety of speeds at which saws are run. I will give an approximate of the speed of saws, which can be relied on with safety. This approximation is as near as can be estimated. No sawmaker has ever discovered any exact tension for saws at a certain speed. I will estimate from the standard speed of saws, which table is given in this book. Saws for portable and light or limited power do not require to be as open as ample power at the same speed. For such mills a 10 gauge 48″ saw may have the center to spring just a trifle more than the center is; if two gauges heavier, it must be stiffer; the same with a heavier gauge. A 52″ may spring a little by pulling back and forth with the hand; heavier gauge may be nearly stiff; 56″ may sag a little heavier, gauge not so much; 60″ must just stand straight; 64″ must dish a little back and forth if power is good and speed nearly up to the standard speed. High tempered saws may not be quite so open. If mandrel runs hot they require less tension. In Part III this will be treated fully for higher speeds.

Fig. 5 shows how to distribute the tension properly, that is, to have the tension properly located. Without the knowledge of this no man can master the saw. Lines 1, 2 and 3 show equally one-third of the saw from the radius. That part marked 3 which is half way between center and rim must be more open than any other part, gradually diminishing as lines 1 and 2 are passed. To illustrate a 60″ saw, 30″ to center for opening saw, hammering should be done no closer than 10″ from the rim and 10″ from the center, the remaining 10″, which is 3, is to be hammered on. This is with a saw with tension first properly distributed. It is often that a saw is too tight on

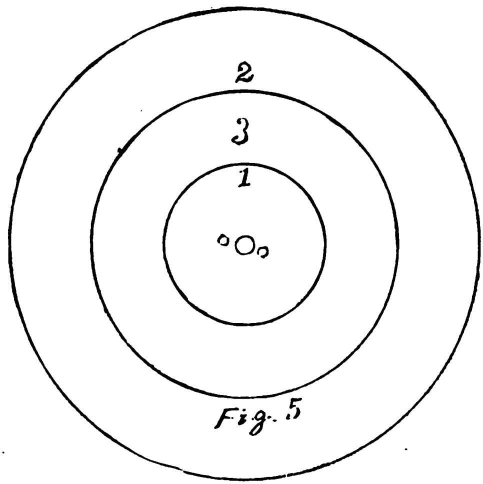


Fig. 5.—HOW TO DISTRIBUTE THE TENSION.

line 2 and too open on line 1. This is done by hammering too near the center, and results in the meanest running saw under the sun. Again, I have seen line 1 too tight and line 2 too open; this does not make as bad a running saw but is dangerous of fracture treated further on.

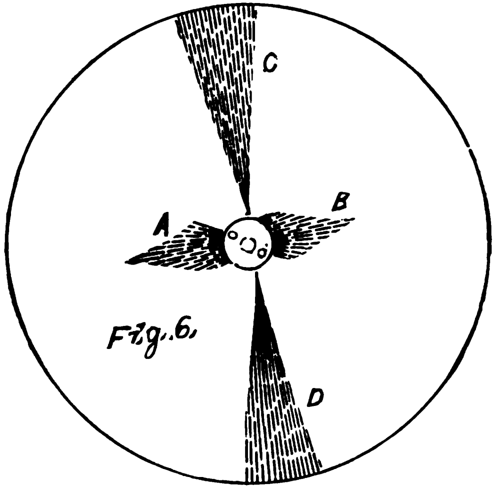


Fig. 6.—SHOWS A TWISTED SAW.

This saw has been partly treated, and will be again treated in "unequal tension." Such saws often bother good men and are very annoying. The first thing to look into in such a saw is the condition of its tension. As previously stated, if a saw is long on the rim it will twist. This must be guarded against. Saws are often jammed and badly twisted, the strain coming against the blade in a side-like way as when a saw runs out of the log or badly jammed. Fig. 6 shows such a saw. This saw is twisted at the rim and collars; by turning it around it will appear nearly or quite straight but when turned half around will show very full. Such a saw is tested on the rim and at center. *C* and *D* show two very high places on the rim, with the straightedge applied in a horizontal position; but when turned at right angles saw will show straight and often light under it. A 30″ straightedge is best to use in the perpendicular position so as to reach close to the collar. By tracing *C* and *D* the twist will be seen often to run clear to the center, diminishing there. In such cases it is not necessary to straighten or hammer clear down to the center, begin at the rim and you will find that one-third, or sometimes one-fourth, of the way down will be necessary, such places are sprung most directly on the edge and require nearly all the straightening done on the extreme edge with saw bedded firm on the padded anvil. *A* and *B* show to be at right angles to *C* and *D*. Very often such a saw will appear full on one side, and at right angles full on the other side. It is often necessary to go right down to the eye of the saw. Such places are removed with the long peine, always applying it on a line with the straightest way of the saw. Sometimes from the fogy way of hammering a saw in segments, causes it to spring on its quarters, appearing as though it was slack on the rim; when such a saw won't yield to the opening in Fig. 3 it may be considered a hard case and is fully treated in "unequal tension."

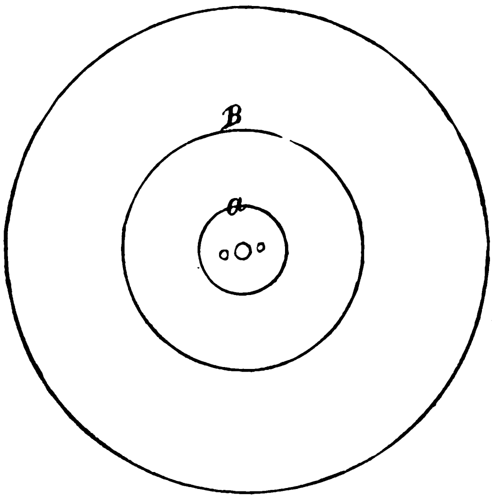


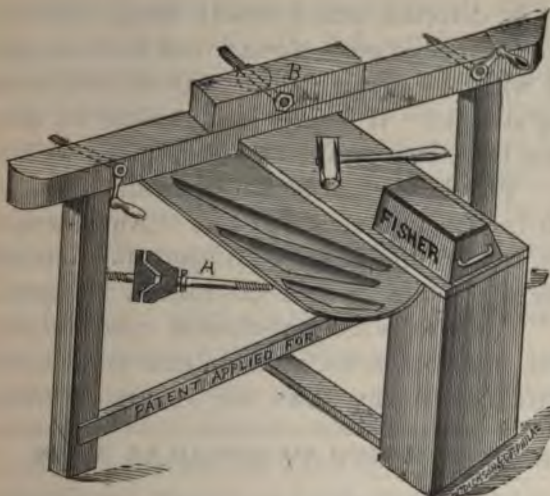
Fig. 7.—CHANGING A SAW FROM RIGHT TO LEFT HAND.

This can easily be done with any saw. The idea among millmen that this cannot be done is erroneous. Fig. 7 shows how this can be done. If saw is of one gauge taper about four blows on line *B* will change it, striking on such lumps as can be found, but little will change a saw. *A* shows that a saw two gauges thicker at center must be set back closer to the center. This is done on the board side in changing a saw from right to left hand. What is wanted is a saw perfectly flat on the log side or a little to the log. Many saws will run the *vice versa* without hammering.

HIGH SPEEDED FAST FEED SAWS.

PART III.

High speeded saws require close and constant attention. On the average mill a saw can be hammered and will run for weeks and months without re-hammering, while the high speeded saw requires constant care, a little hammering every day or so, and to accomplish this I have constructed a patent filing and hammering bench, by which the operator can hammer his saw at will. The special feature of this bench is in the provision of a tension gauge by which the unequal tension of a high speeded saw can be accurately attained.



IMPROVED TENSIONING BENCH.

This illustrates my hammering bench suitable for accurately correcting unequal tension in saws. It is also a good filing and jointing bench and should be in every mill. The screws shown in cut are for springing the saw in a dished form for testing unequal tension, the only correct way. The saw is centered on collar and mandrel *A* shown in place at *B*. When saw is centered and set out by screws, no pull of the hand or guess work is relied upon, which is the only known method. The saw can be revolved and the least variation of light under the straightedge can readily be detected, which closely locates unequal tension, as treated on. No saw can be accurately tested with the straightedge without first being sprung straight. If leaned on the floor its position has to be continually changed, which will deceive. This bench can be built in mill. Tools as shown in cut cost about $15.00. Anvil weighs 100lbs. and is suitable for both band and circular hammering. Size of face 5x8 inches, 7½ inches high. These tools are first-class in every respect.

The speed of saws given in this table is the standard, but many saws are run much above

TABLE OF SPEED OF CIRCULAR SAWS.

SIZE OF SAW.	REV. PER MIN.	SIZE OF SAW.	REV. PER MIN.
8 inches.	4,500	42 inches.	870
10 inches.	3,600	44 inches.	840
12 inches.	3,000	46 inches.	800
14 inches.	2,585	48 inches.	750
16 inches.	2,222	50 inches.	725
18 inches.	2,000	52 inches.	700
20 inches.	1,800	54 inches.	675
22 inches.	1,636	56 inches.	650
24 inches.	1,500	58 inches.	625
26 inches.	1,384	60 inches.	600
28 inches.	1,285	62 inches.	575
30 inches.	1,200	64 inches.	550
32 inches.	1,120	66 inches.	545
34 inches.	1,050	68 inches.	529
36 inches.	1,000	70 inches.	514
38 inches.	950	72 inches.	500
40 inches.	900		

this. This table gives a little over 9,000 feet rim speed, while many saws are run as high as 14,000 feet rim speed. Saws running at the above speed with ample power should be open, as follows: 50″

saw slightly open, center sagging both ways when saw is leaned; 56″ will dish a trifle; 60″ will go through with a jerk; 64″ will require considerable pull, center going through with a "thug." If power is limited saws must not be so open. Saws running as high as 12,000 feet speed, and above, will require 30lbs. pull to set a 60″ saw back and forth. Experience will better demonstrate this. There are so many conditions that no accurate rule can be had. With my bench the dish of the saw can be registered, thus the same saw can be kept exactly to its speed. Saws one gauge thicker in center do not require quite so much opening, neither does a saw with few teeth. Inserted teeth saws do not require as much opening as the solid at the same speed.

HAMMERING SAWS, TENSIONING AND CORRECTING UNEQUAL TENSION.

This may be termed the chief element in fitting up the perfect saw. It is first necessary to go into a detailed explanation of what unequal tension is and how saws are affected by tension in service. Tension in a saw may be more commonly illustrated as temper in a cutting tool. Tension in saws does not apply to temper, but to the condition under which the saw has to work. A saw at a high speed is subject to an enormous amount of centrifugal strain on the rim, which expands that part; and unless the center is stretched to compensate this strain the saw cannot be run successfully. A low speeded saw is not affected as much as the higher and does not require as much tension. In tensioning a saw as treated, is done by stretching the steel. The great secret of this is not in a uniformity of blows, as many think, but is in having the saw of an equal opening at any one corresponding point throughout the plate; that is, on a line of the circumference. The tension should be precisely the same, and as the rim and center is approached should diminish as hereinafter explained, gradually diminishing at that point where action of centrifugal force ceases, which will be fully explained by cuts.

The center of all saws should be stiff, ranging from 6 to 10 inches from the eye, according to size and condition. The great secret comes in locating unequal tension, that is, parts of the saw more open or tighter than others, which is involved in unequal temper. It is a very common thing to see saws opened to appear to proper speed (and in reality are) and the saw won't run. Such a saw may be one side open for a speed 100 revolutions higher than its speed, while the opposite side may have 100 revolutions lower speed than what the saw was to run at, and yet this can't be detected in the ordinary way by standing a saw on its edge, the dish in a high speeded saw being too much for guesswork. Now it will be readily understood why such a saw can't make good lumber and hardly cut a straight board, one side of the saw too large the other side too small. "A saw divided against itself can't run." The large side that is open for 100 higher than speed tends to dish, while the other side tends to snake a reverse action on the rim. Imagine this action on a saw running at a speed of 900 per minute. Could it hardly be expected that such a saw would stay in the guide pins? This saw appeared perfect to the average man. What gets a saw in that condition? There are a dozen reasons why a new saw, perfect, will soon get in this shape, that is, with a tight side, among most of the saw hammerers of to-day, by the prevailing plan to always hammer a saw on the anvil for all kinds of defects. Lumps or sprung places on the rim never appear at any regular intervals or distances apart, but on the contrary, and show lumps to be miscellaneous. Now, this miscellaneous hammering brings about unequal tension; not so much the first hammering, but two or three such hammerings bring about much unequal tension, simply because lumps are not always unequal tension, and where a place is "belted" a series of blows, it invariably turns out to be an unequal spot in high speeded saws. If a man thoroughly understands tension he can correct this; but I have not seen one man in twenty-five that hammered this way that had a perfect running saw. Uniform hammering is by no means advisable to a thorough saw man, and yet it is the only safe way for beginners. Hammering on the anvil for all defects I do not advise. It is best to level up the saw on the pad; this puts it in a condition for determining the unequal tension, otherwise it is difficult to test. All practical hammerers know that strains or defects near the rim of a saw are most prominent direct on the edge of saw. Now, the hammering of the extreme edge of a saw with the cross peine on anvil will curl that part up and make it worse. A lesson on saws may be taken from the tin and coppersmith. Note how particular he is to remove lumps with his wooden mallet. Why? Because to stretch the metal with hammer and anvil would get it in such a shape by stretching it that he could never straighten it. Precisely the same with the saw, the saw being more dense only yields in the course of frequent treatment. Saws are not sent out needing hammer tension, as some are ready to advocate. Hammering on the anvil, as the majority of men do, tends to crystallize the plate, which by no means is argument for any improvement. A saw should be hammered the quickest way and accomplish good results. Saw hammering is fatiguing and worrying, and when a man takes hold of a saw and there is just enough to do to it to encourage him, it is much better than a half day's work and then not be certain whether it is any better or not. In testing a saw for unequal tension it should be hung on the bench, jam nuts set up so as to just leave free movement to saw. Now screws *D D* are set out until saw dishes considerably; revolve saw and note the variation of saw under straightedge, marking the closest places and those that stand off the farthest; take saw off and turn it around, not disturbing screws *D D* if avoidable. Mark all the variations as before. You will notice that some of the marks correspond; if so, it is an indication of unequal tension. That part that stood off the farthest on both sides from the straightedge is a loose place; the place that stood the closest on both sides was a tight place. Note the variation and location of such places, not going closer to the rim than one-third of the distance from rim to center and about the same distance toward the center. Fig. 1 shows how to remove such places, *B* showing the loose place that stood the farthest from the gauge on both sides. *A* is the tight place which stood the closest to gauge, alike on both sides. *A* shows the blows applied directly on the defect. *B* shows that the rim has to be stretched to let the opening out; this equalizes the metal. A saw will often show as many as two of such places as *A* and *B* extending nearer to rim and center. A saw, to be equally tensioned, will stand off the same way almost to a fraction all around, provided saw is true,

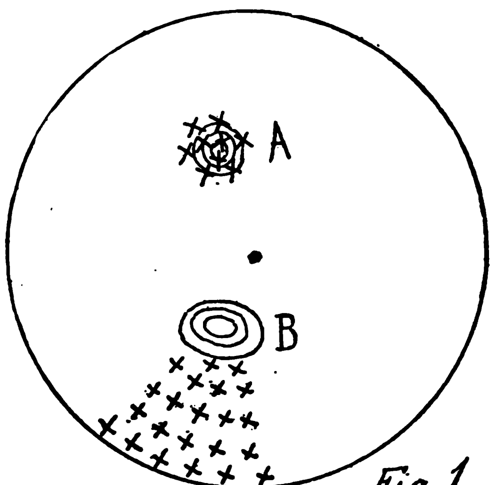


Fig. 1.

which in all cases should be done on the pad before testing for unequal tension. Some places are very firm and require much more hammering than is expected. The same amount should be done on both sides; if there showed to be a slight difference in the saw, then the heaviest blows on the fullest side. This variation can be but little, otherwise it will be a lump instead of unequal tension.

Fig. 2 shows how some attempt to remove such a place as *B* in Fig. 1. The saw is hammered all over except that place, to equalize the tension. Such work is never attended with good results, because few saws are equally tempered, consequently the milder places are opened more than

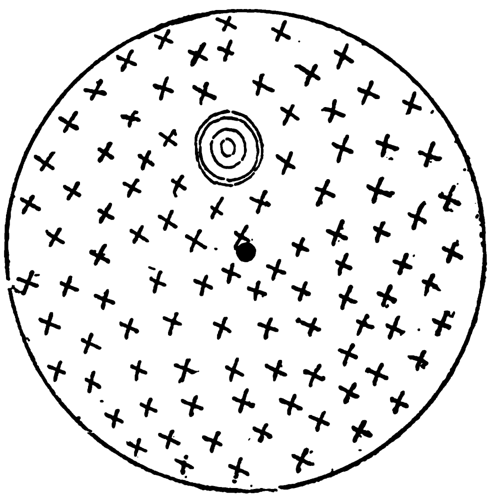


Fig. 2.

the harder, so other unequal places are brought about. I deem it necessary here to make such explanation because to see it in but one light leaves no conclusion that my method is any better than others.

What is wanted in adjusting the tension of a saw is to gauge only from rim to collar, that is, the center. This is where its momentum begins and is not affected here by speed, but should be left stiff; that is, saw not opened clear down to the center. In testing a saw clear across from edge to edge, the drop is so much from the straightedge that there is but little certainty in its distortion. Unequal temper will cause a drop which will indicate more irregularity than there is, thus deceiving a man. This is if saw is not gauged from the center (or near there) the weight of saw will deceive, and when testing across the center such a place as *B*, Fig. 1, may be a soft place, it having that appearance as it is a loose place. When this place is adjusted from rim to center so that saw stands off equally from straightedge, it would not appear the same if the edges of saw were supported and center sagged free, because place *B* would sag more and would seem to be unequal after it had been adjusted as described. Because the saw is softer at *B* does not say that it is on the rim, so if rim is again stretched by testing with center sagging, saw will not have a running tension and will not run well. Tension must be corrected in relation to the action of centrifugal force, then a perfect saw will be the result.

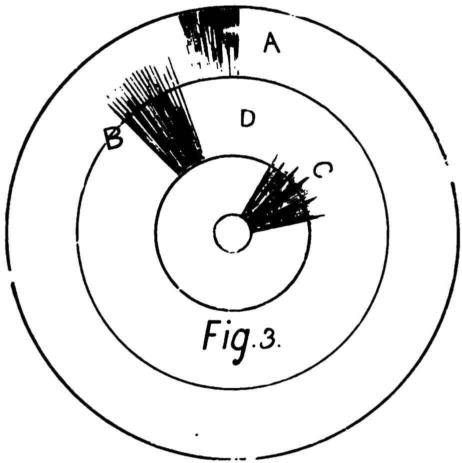


Fig. 3.

Fig. 3 shows the action of centrifugal force and how a saw should be adjusted. *C* shows that one-third of the saw from the center should be left stiff. *D* shows that the opening should begin at line *C* and diminish after passing line *B*. *A* shows how centrifugal force opens the rim and diminishes at line *B*, which is one-third of the diameter.

Fig. 4 shows different positions of saws. *A* shows a saw too open near center, as shown at *D*. *B* shows a saw properly opened, being equally one-half way between center and rim. *C* shows saw opened too near rim. *E* shows the saw with long straightedge applied across it, being opened properly as at *B*. *D* shows a high speeded saw open too near center, as at *A*, a low speed stiff saw will stand off but little from the straightedge. In adjusting the unequal tension of a saw, it is best to have the saw open about to the speed at which

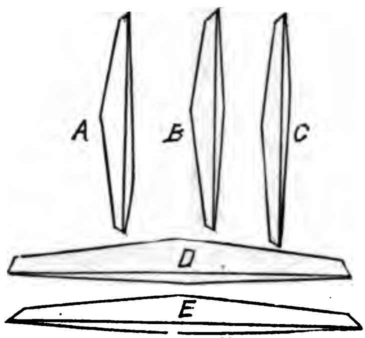


Fig. 4

it is to run, because it will spring easier and show up defects plainer. In tensioning saws, the best plan with high speeded saws is as follows: As all saws grow large on the rim, such saws, when needing more tension, should have the tight places in the tension removed. This done will invariably bring the tension up to its proper opening. To illustrate this: A saw needing a little more tension, by examining for unequal places one or more firm places can be found. They may show but very little. Now, such places removed may make saw a little too open; if so, examine for a place a little loose, as *B*, Fig. 1, and remove it; then the saw will be perfect. This is why I say that an expert hammerer will not hammer uniformly, but as to the condition of the tension, unless overhauling a saw or changing the speed considerably.

It will be noticed in testing a saw for unequal tension on my patent bench, that a saw will stand off farther for a soft place (alike on both sides of the saw), and will stand closer to the straightedge for a tight place. In a plainer term, loose places appear as though the saw was thinner at that place, tight places appearing thicker. This is when the saw is tested from the concave side.

BROKEN SAWS.

WHAT BREAKS THEM AND HOW TO REPAIR. ANOTHER FORM OF UNEQUAL TENSION.

Broken saws sometimes seem a mystery for the cause; but nine times out of ten there is a cause. Fig. 5 shows a cracked saw—two cracks on the rim. Seldom but one crack forms in the rim of a saw as shown, which should have a three-eighths or

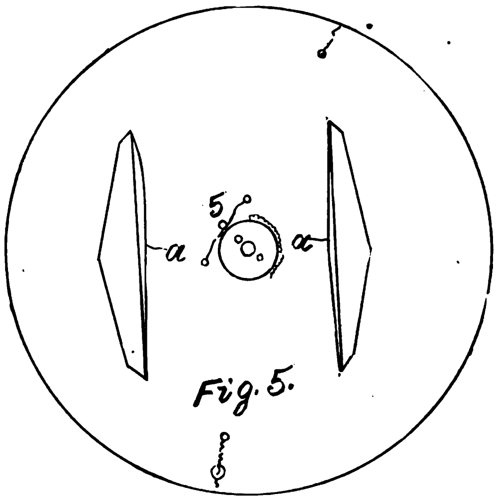
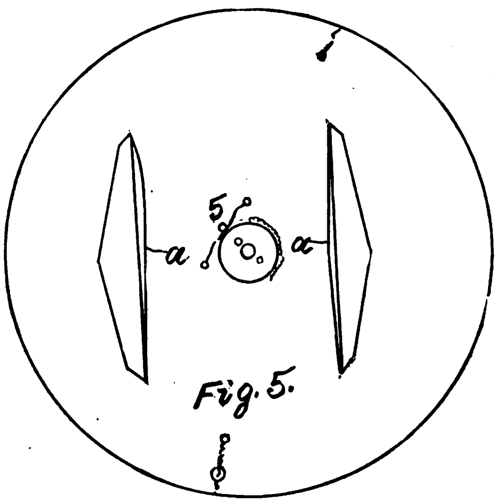


Fig. 5.

one-half hole drilled at the extremity to prevent going any farther. Cut shows the neglect of drilling when a crack appears. It takes but a short while to ruin, if not to burst, the saw. Cut shows two holes; that nearest the rim is counter sunk on both sides to receive a soft iron rivet, copper will do. It should be riveted tight and dressed down smooth. Do not use hard metal, as it will spring the crack open. Such places are invariably caused from a distorted or unequal tension, treated farther on. 5 shows a crack in the center. This is caused by saw crowding out of log, or from jamming; small collars are a frequent cause of broken saws at the collar. This is a very important item which seems to be entirely overlooked by manufacturers. Thin saws can be successfully run on large collars. A 60″ 8 gauge saw on a 5″ collar will not run as well as a 10 gauge 60″ on an 8″ collar. This large collar theory will astound any who will think for a minute how much stiffer a saw is made by clamping only a fraction more of the plate. No saw is as stiff standing on the floor on edge as when screwed up on collars, and while the difference is from 2 to 3″ in size of saw, is but a small item where a thin saw is necessary in valuable timber.

Invariably the tension of a saw is extended too close to the rim, as shown in Fig. 3, the dark lines showing the tension. In locating the condition of such a saw, it will stand off from the straightedge as at *A*, Fig. 5, *D* being the center line which should show the most opening at that point; but it would be noticed that the most opening is above *D* and nearer the rim than center, line *A* showing that the tension is not run to the extreme edge, also shown by position of dark lines. *A* shows a place ranging from 3 to 5″ in from the rim, according to size of saw. Great trouble is often experienced in cold climates from broken saws, which could often be obviated. Cut-off saws often suffer from fracture. Such saws should be stretched on the rim, say hammer two or three times, beginning directly at the throats of the teeth. This, of course, will necessitate the opening of the center. All such saws should be run as slack on the rim as possible. They will stand more abuse, which they



certainly get. The leaving of case-harden from the emery wheel invariably will crack a saw. While high speeded saws stand from the straight-edge, as *C*, Fig. 4, it is a safe plan to open the rim a little. Firecracks in tempering often cause saws to crack. Defects that have never been discovered in steel cause fracture. As small a thing as a mark at the throat of tooth will sometimes cause a

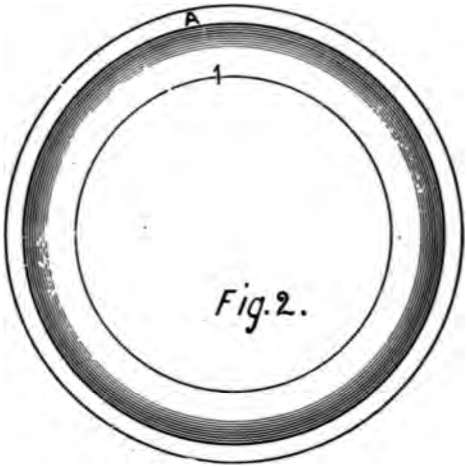


Fig. 2.

fracture, to say nothing of the filing square corners, etc., which should be guarded against, especially in high speeds.

Fig. 8 shows the worst form of unequal tension that can be in a saw, and is brought about, as may be said, in a practical way. A saw can be in this condition and show up to be equally tensioned from the ordinary test, that is, no tight and loose places, and not have a running tension. *A* shows that the saw is too open near center, caused by hammering down to the collar. This saw is illustrated at *A*, Fig. 4, the straightedge showing the most opening near the center. *B*, Fig. 8, shows a tight line in the saw near where it should be the most open. To stand this saw on edge and give it a shake with both hands it will be noticed that

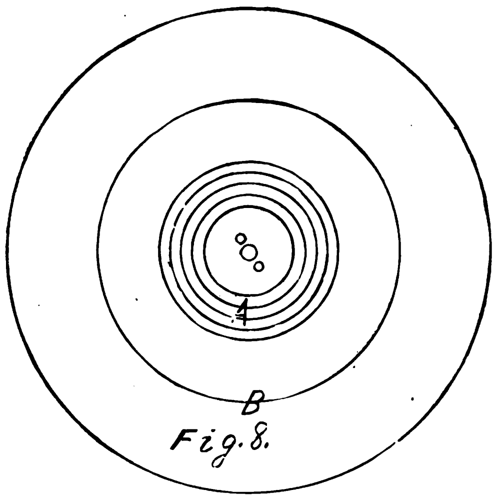


Fig. 8.

UNEQUAL TENSION OF ANOTHER FORM. A DECEIVING SAW.

line *B* remains the firmest part of the saw, the rim quivering very similar to a saw that is too slack on the rim. If my rule is followed by keeping a saw the most open half way between center and rim, no such trouble will be had. Such a saw as Fig. 8 will stand pretty close to the straightedge to nearly half way from the rim; this is when the saw is dished. Such a saw is not so much affected only in high speed. This saw will dish back and forth with a jerk, and yet the rim is so slack that saw will snake and not cut a straight line. I have seen such a saw 66″ run 6 inches out of its course without heating but little, the rim being loose, the center dished, allowing saw to almost cross the log. Over one dozen saw hammerers tried to remedy this saw only to make it worse, hammering first the rim, then the center, omitting part *B*. Such a saw wants close observation when shaken while standing on edge. A high speeded saw in good condition will shake more at the center from a vibration. It is not expected for the rim to remain still, as it will vibrate a little, but saw should sag back and forth to within a few inches of the rim. Such a saw is remedied by hammering on line *B*.

Fig. 9 represents a peculiar form of twisted saw caused by unequal tension. This saw may be termed sprung on the quarters. What gets a saw in such a condition is hammering in segments from rim to center, opening certain parts more than others. Such a saw will appear as though it was too slack on the rim; but when treating the center it gets no better. The cause of this is that there are as many tight lines running from rim to center as there are loose places, so the hammering that expands the saw opens these loose lines as much as the tight ones are opened, so the saw in reality is made no better. The only remedy for these tight

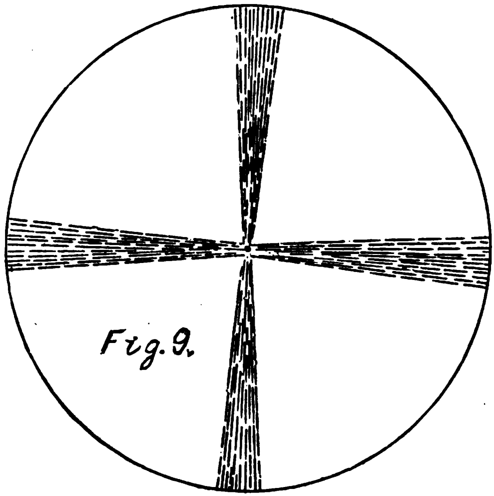


Fig. 9.—ANOTHER FORM OF UNEQUAL TENSION. A TWISTED SAW.

lines is to hammer from rim to center in the same manner as has been done. This is the only way to neutralize the tension. Such tight lines are located by resting the saw with one edge on the anvil while on the bench and spring the saw up and down, noting the parts that are the stiffest, marking them and moving saw to be certain that such parts are the stiffest. Hammering with the cross or long peine soon brings about such results. Only reckless hammering can get a saw in that shape.

There might be much more said about unequal tension, but if these instructions are complied with any saw may and can be made to run better. I will say that such saws are often found where a half dozen or so of traveling hammerers have been. When a saw won't stiffen (if too open) by stretching the rim there is this trouble. The same way in the center of saw when saw does not appear to improve in tension after much hammering. Keep in mind that a loose saw on the rim often assumes such shapes (winding), but when treated half dozen lines in center a great change is noticed, while the former will not improve.

BAND LOG SAWS.

It is not necessary here to enter into any discussion of the utility of the band saw for converting choice logs into lumber. They have come to stay, and their introduction generally is only limited to the skill to be had in their care and operation. They are no more an experiment but a success. Their capacity is only determined by the skill in charge, viz.: the filer. Unprecedented results are almost daily heard of and their capacity has never been reached. Some records show a greater output in the same time than the circular, showing as high as one hundred and fifty thousand feet cut in eleven hours. The chief merit of the band saw lies of course in its economy of saw kerf—cutting out but one-eighth inch, against the five-sixteenths inch of a circular. Another advantage is its ability to saw wide boards or plank from large logs. Every mill man knows that this cannot be done with two circular saws without the board showing more or less of an off-set on its face, owing to the practical impossibility of getting the saws to "track" in the same line. There is no scoring the face of the log as with the rear teeth of a circular saw. The cut as a rule is smoother, and consequently there is less waste in surfacing, so that lumber may be made nearer the ultimate thickness than when sawed with a circular. These are considerations that directly affect one's pocket-book, and if any doubt exists as to their validity there are means at hand, happily, that will enable every person to investigate for himself to his heart's content. There are nearly one thousand band-mills in use in the United States and Canada. There is a growing disposition observed on the part of some users in favor of wider saws than have hitherto been employed, and I am inclined to join them in their belief. I think that a blade ten inches wide at the beginning and 14 or 15 gauge is bound to give satisfactory results and run well for a long time. It can wear down to six inches, or even less perhaps, without seriously affecting its usefulness, but by having it good width at the start its life is prolonged to just the extent that the additional inch or two adds to the circular. Hence, it is economy to have the saw as wide as possible at the outset. In connection with this point the query might naturally be propounded: If a ten inch blade is good, why is not one twelve inches, or even wider, better? The answer would be: For the reason that saw makers, as a rule, are not in favor of anything wider than ten inches, owing to the trouble they experience, with the facilities at their present command, in properly tempering blades of greater width. The day may come when wider saws will be used, but for the present ten inches is the limit for general practice.

I shall not confine myself to any particular make of mill. It may be said that all manufacturers have mills doing good work. What the band-mill wants to-day is a perfect saw—a saw that will stand up to the work and make even lumber. One serious trouble in band-mills which the makers have endeavored to overcome is the "overthrow" of the upper wheel, which is caused in various ways, principally from the want of sufficient motive power to maintain a uniform speed. It prevails among many that as a band saw cuts a much less kerf than the circular, less, or even the same power, will operate the band. This is not so. On the contrary, the band must have more power behind it. Overthrow transmits the slack side of the saw over to the cutting side, thereby making dishing boards, especially in broad cuts, where the power may vary. Such lumber does not show this defect from its edges as the circular does, but shows up in surfacing. Great stress is put on the saw by this overthrow and tends to crack the blade. Another cause of slight overthrow and bad lumber is badly fitted and too many teeth. The tension may be good, but if the points of the teeth are not in good shape this resistance, or stress, though of short duration, is thrown upon the imperfect saw while passing through knots, hard and tough parts of the log, beyond the sawyer's conception. Such is the case with too little set, too heavy back set swaging, which is hard on all kinds of saws which are less delicate and more sensitive than the band. Another detriment to verticle saws is engaging the ends of square cut logs, causing a sudden stress and vibration imparted to the cutting edge. The inclined mill overcomes this to a certain extent, but is attended by disadvantages, in which the attraction of gravity is not overcome in the inclined position of the wheel. The slightest defect in the bearing on the balance of the wheel imparts a wabbling tendency which seriously affects the running of the saw.

TEETH—THEIR DISTANCE FROM POINT TO POINT. FILING AND SWAGING.

From the authority of the best manufacturers and users, from seven-eighths to two inches is the limit from point to point, governed by the kind of wood and capacity of mill. It is a fact that the band saw can have too many teeth, and when such is the case is attended with serious results.

Teeth that are too close together have many disadvantages—first, difficult of properly swaging, more sharpening and a choking or packing of the dust between saw and log, especially in dry and hard wood; more power is required and the saw runs more or less warm on the tooth edge, which causes it to snake. Teeth too close invariably will not allow sufficient hook without too round a back; while the back may clear freely, a "roman" back will not stand the feed. What is wanted in a band saw is as little friction on the teeth (or tendency to shove the saw over) as possible. Many saws are ruined quickly in this way. Too many teeth when in nice fix are not the best for the saw, to say nothing of stub points, heavy round corners, irregular set, etc. All this is a detriment to the saw, and in hard, dry logs it is no common thing to see a saw not take it. If filers would file and keep the teeth in the right shape, teeth 2″ apart will work better, but not with sharp corners filed in throat or too narrow a throat, as will be treated further on.

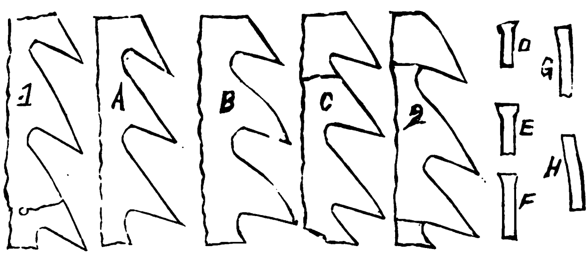


FIG. 1.—SHAPES OF TEETH, FILING AND SWAGING.

Fig. 1 shows various shaped teeth. It is an extremely difficult matter to impress filers with the importance of a perfect shaped tooth, that is, to maintain it. It can be noticed among what may be called good average filers that two saws fitted up may appear precisely the same in appearance as to finish of teeth, and yet one saw will cut just twice the lumber that the other will. The expert filer will very readily detect the saws. The practice among the best filers is to be confined to no particular pitch of teeth, owing to the working condition of the mill and the difference of timber. Even the same kind of timber in different localities requires a slight variation, for only a limited quantity of work from the saw can be had; but where capacity with good sawing with care of machinery is what is wanted, one-quarter pitch to a tooth three-fourths of an inch long may be considered the best tooth for soft wood. Tooth *A*, Fig. 1, is the best tooth. This shows a tooth one and one-half inches from point to point. Hard wood requires a shorter tooth and slightly less pitch. Tooth *B* shows the average tooth among mills. This tooth will pull very heavy and will tend to crowd the back guide. *C* shows a tooth with a sharp throat that is too slim. Such a tooth may not crack the saw, but there is danger of it, as shown in cut. The dust will pack as a wedge. There not being sufficient clearance, teeth *B* and *C* will pull very heavy and will dodge, from the fact that the backs are too high, tooth is too thick. *A* shows the best tooth for all kinds of sawing. *A* cannot have as large a throat as *B*, but it does not need it. If *C* had a straight back and round throat, tooth would clear well. The tendency is to hold the dust against the front of the tooth.

Unless the back is of proper shape, saw will not stand up. The back of the tooth has more to do with a nice cutting saw than the front. Many do not believe this, but an experiment will demonstrate it and costs nothing.

Tooth *A* cannot be used on saws of teeth too close together, that is, saws of one and one-fourth inches, and some are less from point to point. In such cases it is best to run a little less pitch to maintain as near a straight back as possible. Such saws of course do not require as long a tooth, they being closer together.

Tooth 1 is also a very good tooth and is much easier kept up on an automatic sharpener. 2 shows the result of pointing up with the file square corners, producing cracks. Tooth 1 will do very well for light or limited power, as it will cut lighter than *A*. Many band saws do not have sufficient power. They require more power than a circular. This is necessary in keeping up the momentum of the wheels. If tooth 1 are as close together as one and one-fourth inches, spring and partly swaged set may be successfully used.

FILING AND SETTING BAND SAWS.

They should be full swaged set. For resawing, machinery and variety saws, they are sprung set. *D* shows properly swaged and set. *E* shows too heavy a swage—not too much set, but too heavy and bulky a corner. Such a tooth will pull very heavily and snake, especially in hard or uneven grained logs. *F* shows tooth for hard wood, which has less set and a heavier corner. If a saw is true and well hammered very little set can be used. Too much set is invariably used. A true saw 15 gauge will run well with one-eighth set, which is sufficient. A true saw with just the proper set is easier kept up, the saw runs lighter and keeps itself cleaner. Only a close set can be run in hard wood, especially if dry or of a brittle nature.

Spring set teeth are not advisable on heavy feed. It is often that saws have too many teeth for power. In such cases the right kind of a spring tooth, as at *G*, will run much lighter and will cut well under moderate feed, and will stand crowding if teeth are not over one and one-fourth inches apart. *H* shows a bad tooth that will not run. The set will close and there is danger of its springing into the work in tough knots. *G* is sprung near the point, which alleviates friction.

With all the improved tools now to be had, band saws can be kept up in the most approved manner. The automatic sharpener and swage are indispensable, especially the former. There are some good hand swages that work well. The teeth should be sharpened to a fine edge. This can be done on the automatic machine when there are plenty of saws in stock. A saw will not work well sharpened hurriedly on an automatic; neither is it a good plan to point up with the file. Either make a practice of it or not at all.

Considerable filing has to be done where gravel and spikes come in contact with the saw. In swaging it is best to use a special swage. There are good automatic swages, but a good plan is to have a hand swage. The park swage being about the best in connection. The teeth should be swaged as much as possible from the front of the tooth. The teeth should be kept just the proper shape; then set the swage so as to draw out the tooth, and by no means to upset or stub the point. The points of the teeth should be kept uniform in length. If an automatic sharpener is used, the back edge of saw must be kept straight, or it will be impossible to keep a nice, true running edge.

The teeth of band saws should be sidedressed to an even set, with a slight underfiling to relieve friction, caused by a square set, as shown at *E*, Fig. 1. It must be borne in mind that the band saw is very sensitive, and a more perfect saw in every respect should be the aim of the filer. To increase the feed, give a little more hook, but in all cases the teeth must be nearer perfect. A saw with badly fitted teeth may have too much hook, while the same hook would not be sufficient if point was in perfect shape.

HAMMERING BAND SAWS.

Hammering band saws requires great care and precision. I shall not introduce any new method from that in general use by practical filers. The secret of success lies in the saw being properly hammered. Band saws are hammered in a similar manner to the gang saw. The principal feature is to prevent the saw from fracture and retain its proper tension. This is accomplished by not extending the tension to the extreme edge, as will be further illustrated. The tension of a band saw should be such that its central part will be slacker, or longer, than the edges, so that the edges of the saw will be the tightest and maintain its position on the wheel. The idea may be explained in a simple manner as follows: Take a piece of ribbon or other similar substance, grasp it in the center and draw tightly. It will be noticed that both edges are rendered slack and is easily vibrated. Then change the strain to the edges and it will be readily seen that it is firm and stiff. Though simple, the principle is explained. The central parts are hammered open, as shown in Fig. 1. *A* shows how the tension is applied, hammering, as shown by the dotted marks, extending nearly but not to the extreme edge.

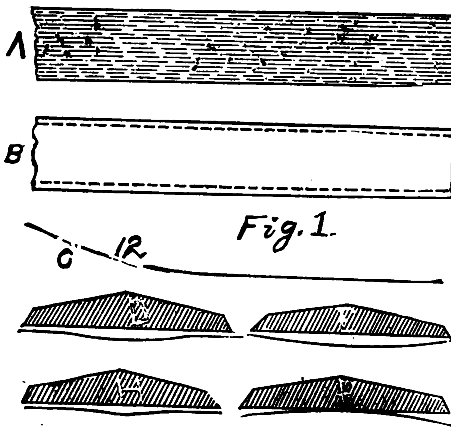


Fig. 1.

In tensioning a band saw only a round face hammer should be used, and it must be perfectly smooth. Anvil should be heavy so that there will be no rebound. The great trouble with most men in hammering band saws is that entirely too heavy blows are applied. This soon gets the saw lumpy and requires from 25 to 50 per cent. more power to pull it. All this comes directly on the saw. Such saws require much more set, which makes it liable to dodge or snake and liable to fracture. A true saw with just the proper set will run much truer and stand more feed. A good plan is to have some oily waste on hand by which the saw can be slightly oiled. This will prevent marring the blade. A doghead hammer is best, of not over four and one-half pounds weight, though a balanced hammer may be used, care being exercised that the blows are applied plumb. The idea of applying glancing or angling blows to expand the steel in but one direction is erroneous. *B* shows the plan of stretching the edges of the saw when the tension is too close to the edge, the blows being applied close together directly to the edge. *C* shows how the saw is supported in testing the tension, 2 showing the straightedge as applied while saw is in this position. It should show light under the straightedge, say one-thirty-second of an inch in an 8″ saw. A convex straightedge is best, as there is no guesswork as to the amount of opening. *D* shows how the saw should sag when properly tensioned, the saw resting close to the straightedge, or nearly, at each edge. This shows that the tension is not run too close to the edge. *E* shows tension too close to edge, which will cause saw to crack; besides, such a saw almost continually requires hammering, as the least gumming elongates the tooth edge. *H* shows a saw with tension too far from the edge. Such a saw will not run true and will snake, slipping on wheels and tending to run off, running unsteady. This saw is open in the center, but the edges are slack, very similar to *F*, which shows a saw tight in the center. This needs no further explanation.

These defects are located with the saw in the position of *C*, saw being lifted with the left hand, straightedge applied with the right. A good north or east light should be had. Many argue the point that the tension must be run close to the edge to produce good results. True, a saw will run better, but this is nothing in comparison to preventing a broken saw. There are exceptions, and some saws have run remarkably with tension close to edge; but by no means should this be practiced. In narrow blades it is often extremely difficult to get a saw to run true. The better plan which all saw manufacturers and mill builders advocate is wider saws, some mills using 12″ saws to No. 14 gauge. Such a saw properly fitted will stand more feed than any circular. Wide saws have many advantages: can be strained tighter, have more contact, and can be made stiffer, without the liability of breaking. Wide saws will not make or cut as dishing as a narrower saw. Narrow saws tend too much toward the principle of the narrower shop saw, viz.: cutting an irregular course.

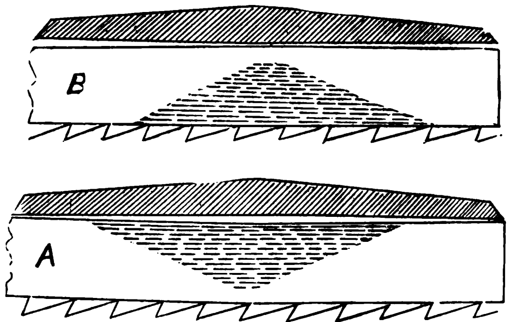


Fig. 2

Fig. 2 shows a crooked back saw and how to hammer it straight. *A* shows saw long on the tooth edge. A saw tends to get in that condition. Promiscuous hammering will get a saw in that condition, which is explained farther on, which also causes a saw to vibrate to and fro on the wheel. This is a very serious defect in the way of making a good running saw. Such places in spots in a saw cause this vibration. If saw is elongated on the tooth edge it will crowd hard against the back guide, and often cannot be regulated by tilting the upper wheel. *A* shows how to hammer the back of saw, doing most of the work on the edge, gradually diminishing to the teeth. Great care must be exercised to have the tension right when back is brought straight, otherwise much more work is necessary. The back of saw should be a trifle full. This will put most of the strain on the front or tooth edge, making the saw much stiffer. A perfectly true straightedge should be used, saw lying flat on leveling table. The tooth edge seldom needs opening, and when necessary should be done the same as described on the back. In no case should the saw be cut or marred on the extreme edge, which crystallizes the steel. Cracks can often be traced from such places. In fact, the hammer should not show a print. Light blows and more of them are the life of the saw. In stretching a band saw, the same amount of work, as near as possible, should be done on both sides, otherwise the saw will not run so well, but will tend to leave that side too much from the straightedge. Little attention is paid to lumps in tensioning. If saw is very lumpy or twisting it must be straightened before a uniform tension can be determined.

STRAIGHTENING BAND SAWS.

This is done on a leveling table. The saw is laid flat on the table and all lumps located with a 12″ straightedge, applying it straight across, then at different angles, locating any twisted places that may appear. Such places always start from the edge and will be found the most prominent there. Such places are located in the ordinary way by applying the straightedge at right angles, applying the blows with the straight peine parallel and in the direction of the straightest way of the saw.

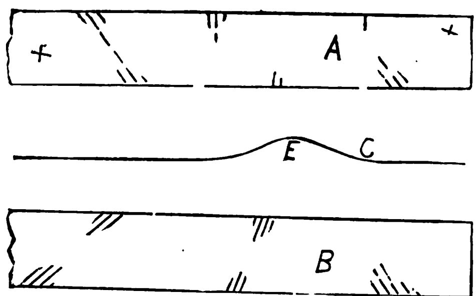


Fig. 3.

Fig. 3 shows the application of blows in straightening, *A* showing that most of the blows are applied directly on the edge of the saw. Here is a great mistake made by many, that is, not being impressed that a saw springs more on the edges than at center. Nine-tenths of the straightening should be done on or near the edge. Band saws spring more in the shape of a twist than in round lumps, and when a saw shows to be crooked on the edge the long peine hammer is always used, and nine times out of ten the saw will be straight and show but few lumps. If the round peine hammer is used on the edge of the saw it cannot be straightened without raising a lump on the other side. The extreme edge of the saw will tend to curl or lift up. When the straightedge is applied parallel with the saw and a lump is located, very often it will not show when applied across the saw. Sometimes lumps are found in the center that show the same in different positions of the straightedge. In such cases the round peine hammer is used.

B, Fig. 3, shows a bent saw, also shown at *C*. *E* shows a badly twisted or bent place. Saws are sprung in this way by being thrown off the wheels. When such places as *E* will not yield readily under the hammer great care should be taken not to fracture the saw. It should be sprung down to a solid bearing on the block, that the blows be applied as firm as possible. Such places may be peined down if desired. Sometimes it is necessary to heat the saw here. This is done by heating a heavy piece of iron or tongues and heating that part to a dark red heat, which will allow the saw to be bent back. This must be done while the saw is hot. This draws the temper, but the proper tension will not affect its running. Very often such places have to be cut out and a piece soldered in. This can easily be done with good soldering tools.

The greatest detriment to the longevity of the band saw is the steel crystallizing, and this is brought about no quicker than with too much hammering, not only too much hammering, but such pounding as most men do. After a saw is once got in good condition it requires but little hammering to be kept up. The man who is continually belting away on a saw is not the man that will succeed.

FRACTURED SAWS.—UNEQUAL TENSION.

A glance into nearly every file room will demonstrate that something is wrong from the number of broken saws. Saws are fractured in many ways, nearly if not all makes with exceptions. Some make saws that will run without fracture if properly treated. Tension too close to edge, too much tension, will tend to fracture. Unequal tension is another cause. A place of no more than 6″ of unequal tension, that is, too close to edge, will endanger a saw. A saw should have precisely the same opening and the most directly in the center, unless a narrow saw with broad face crowning wheels, which is seldom the case; but when such is, the tension must be a trifle toward the back from the center, so that the teeth will clear the edge. Especially along the front and back, the opening must be the same. The saw crowding against back guide, glazing and often case-hardening the back, where there is any trouble of this kind, a piece of soft emery wheel should be held against the back edge while saw is moving slowly. This will produce a new surface and relieves all such anticipations. Saw should run with teeth as far over as possible, with back guides set so that the set of the teeth cannot be backed on to the wheel; but a saw in good order will almost keep its course on the wheels. It may be said that it is of the utmost importance to keep the wheels clean. This is a great annoyance in many mills, especially with too many teeth and slow feed. A fine powdered dust is cut which the teeth partly carry around and deposit on the edge of the wheel. This, of course, adds to the strain on the edge. Saws often have the strain too much on the front edge, especially where the back is kept convex, as many do. Irregular motion is very hard on a saw. As the saw enters the cut a slowing motion causes considerable overthrow, especially with heavy upper wheels. It is a great mistake with many in erecting band mills in not having ample power. The calculation should be for twice the power that the circular requires. In the first place it requires as much power to keep the motion of the wheels up as it does to drive the saw. An automatic, closely regulated engine must be used for good results. That checking of speed throws considerable strain on back or slack side of saw, which results in fracture where there is any defect in tension or on the edge of saw. This checking motion makes very bad lumber, that is, bad places, by the center being cut in a concave shape. As stated, too sharp or narrow a gullet must not be used, especially with a "roman" back tooth. A straight, or as near so as can be, should be used, and extra precaution taken that emery wheel does not case-harden. Wheel should be kept free from all glaze or greasy spots with a clean cutting surface.

BRAZING BAND SAWS.

This is a very particular feature, and while it is easily accomplished with the proper tools, many filers are troubled about making a good job. One important part is to get a good, smooth, even lap. This allows the solder to be of uniform thickness, which adheres better. The scarfing may be done with a milling or grinding machine, or may be scarfed with a file and scraper, being careful to get it uniform. On 8″ saws and above ¾″ lap is plenty. Narrow saws require much less. Every mill should have a good soldering outfit, which I need not describe. Use silver solder, which can be had for the express purpose and of any width, which should be just the width of the lap. Clean the laps and solder with chemical pure muriatic acid; place in position with the back edge perfectly straight. Irons should be heated to a bright cherry red in a clam charcoal fire and applied quickly on the lap, clamped tightly, remaining until saw has nearly cooled. Then remove and if joint is sprung a little straighten it down before saw gets entirely cold, as it will yield better and not be as liable to affect the joint, care being used not to strike too heavy and hammer the joint as little as possible. File off any spurious solder and make a smooth joint, and tension to the requirement. Some recommend pure silver filings 15 parts, pure white brass 5 parts, copper 2 parts, place the powdered metal between the laps, then with a blow pipe and powdered charcoal heat until the metal fuses. This requires considerable heat and is not generally used, unless among narrow saws. Silver solder can be had from any saw maker. If it is not good, braze will not take. Apply irons immediately after applying acid.

NARROW BAND SAWS.

Such saws require but little tension aside from keeping the edges straight. This is accomplished by stretching the blade gently back to the teeth. Round edge files should be used to guard against cracks. Sufficient pitch should be given to prevent saw pressing against stay pin. The wheels should be kept clean and true. Great care should be used in starting the saw, to not start it too quick. Straightening such saws can be done while it is on the wheel by slacking the saw, then with a short straightedge mark all the defects, using a light, straight, peine hammer against a smooth-faced mallet. Defects can be easily located with the eye by pressing saw back to a perpendicular. The object of slacking the strain is to let such defects show themselves. In tensioning or stretching the saw, it is best to remove it from the wheels and use a long straightedge, making the back perfectly straight. Then the saw will run steady.

SPEED OF BAND SAWS.

The speed of band log saws ranges from seven to nine thousand feet per minute. Nine thousand speed can easily be run if mill is well set, good workmanship and wheels well balanced. The latter is very important and requires the greatest precision to get them in perfect running balance. Power is another important item. With ample power and close regulation a higher speed may be attained; but on the contrary, saws should not run as high as eight thousand feet, and some even seven thousand. The saw cannot do good work at too slow a speed; yet it is dangerous to the life of a saw to run at a varying speed with limited power and bad regulation. Small saws are run at an average of four to six thousand feet, which greatly depends on the condition of the saw and wheels.

FOUNDATION CARRIAGE AND TRACK.

The foundation of the band mill should be very solid, built of brick and concrete, with a very broad, deep base. The mill should not be set directly on the mason work, but should have timbers between. There are instances where band mills would not run, being set directly on mason work. This was due to a slight defect in the balance of the wheels. The carriage and track should be perfect, built independent of mill frame, solid, level and perfectly straight. Steel turned wheels are better than chilled. They run and wear smoother. The carriage itself should be in perfect line, with no end motion in bearings. This calls for a good offset device, which should be under immediate control of setter.

SAWS ADAPTED TO MILLS OF SMALL CAPACITY. FILING, SWAGING AND GUMMING.

PART I.

In all books published on filing saws, none have been gotten up to be of practically any value to the filer. They recommend a certain style tooth, etc., as being universal, regardless of the capacity of mill and kind of timber to be sawed; consequently when the filer or sawyer applies the tooth or saw he is surprised at having worse results. There is as much difference in a saw adapted to a mill of five thousand feet capacity and one of fifty thousand capacity as there is in the cutting of the mills. Even saws of same size gauge and speed do not require to be near alike in condition. This I will plainly demonstrate. The reader who applies the style of tooth I recommend will be more than surprised at results. A common fault is too many teeth. Mr. A. is having good success with fifty teeth in his saw. Mr. B. is not doing well, but, to improve matters, imitates Mr. A., gets a saw with fifty teeth. His saw had thirty, the proper number. To his great surprise, saw will not go as well as the old one did. I mention this as there are thousands of similar instances in the mill business. Too many teeth consume nearly fifty per cent. more power, besides making twenty to thirty per cent. bad lumber, especially in hard wood, which is enough to break any man. Saw soon has to go to the repair shop, and all such delays and expenses cut a man's pocket strings. There is no reason why the small mill cannot saw one thousand feet of lumber just as cheap as the larger mills.

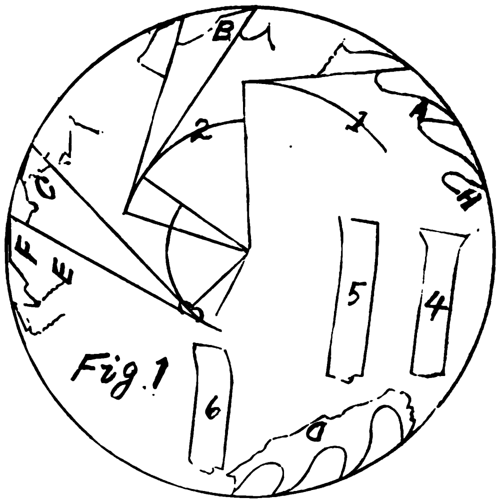
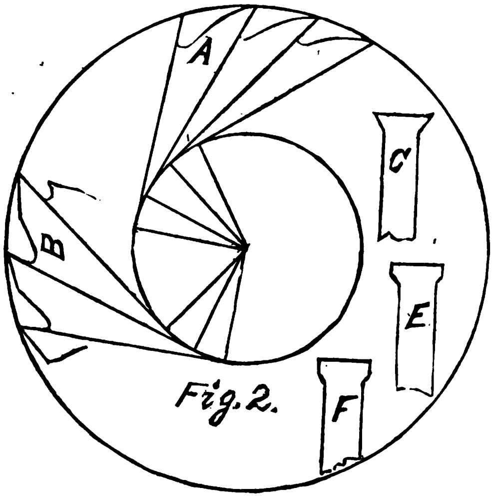


Fig. 1 shows a variety of teeth, showing shape of teeth and manner of setting. Tooth *A* shows the most economical tooth in the consumption of power and saw plate. This tooth is adapted for both hard and soft wood, the latter requiring a little longer tooth. All saws will stand more feed in soft wood. As an approximation, hard wood teeth should be from one to one and a quarter inches long, while soft wood may have a tooth one-quarter inch longer—from three-quarter inch to one and one-eighth inch gullet, or throat. Tooth *B* is a tooth that will run very well and is adapted to frozen timber, being very stiff. It is also a very good hard wood tooth, though it has not quite sufficient pitch for easy cutting, it having one-half pitch while *A* has one-third. *D* shows the style of tooth used by many in hard wood, which is not a good tooth. The idea of throat room being the consideration, the back is "scooped" out. Only in the softer logs will this tooth run to any degree of satisfaction, and will not run at all in hard buts or dry logs, the dust being cut so fine and of a mealy nature passes the throat and packs between the saw and log, heating the rim badly. The reader can recall many such instances. Too many teeth brings about precisely the same result. *C* and *F* show teeth that may be found among some mills, and need no discussion further than that the result invariably is a cracked saw, as shown at *E*, which is the result of filing square corners. *A* and *B* are the teeth to be relied upon. If a burr gummer is used the throats may be under cut, as at *H*. Saws of small capacity should not have many teeth. For hard wood sixteen teeth to every inch of feed is plenty. If the filer swages well and has no trouble in keeping the corner of teeth, twelve teeth may be successfully used. Twelve teeth is about right for soft wood. Very thin saws, ten gauge, should have not less than sixteen teeth for any wood. Such teeth must not have too large a gullet for hard wood. Soft wood is all right with larger throat. A saw for fifteen horse-power should not have over twenty-four teeth, and thirty for a twenty horse-power. For swaging and setting I advocate generally the double spread set, as at 4. Some prefer such a tooth as 5 sprung and partly swaged, but this style of tooth will not hold good with the number of teeth that I recommend, as it will require at least twenty teeth to every inch of feed. In small mills where there are too many teeth, changing from a double spread to a spring tooth will help matters wonderfully. 6 shows a tooth that has a rounding corner. This tooth will not run well and will call for more power to drive it. It should be filed sharp with outside corner a little longer, then swage a little. Never attempt to swage a tooth that is very dull. If your saw is disposed to crumble, file to almost an edge, then it will swage without splitting, as treated farther on. In gumming such saws great care should be exercised not to heat the saw with an emery wheel; neither crowd a dull bit in a burr gummer, as it will stretch the rim and soon require hammering. The emery wheel is in most general use and is the best. Do not attempt to gum out too long or slim a tooth, as the saw will be heated more or less, besides changing the tension so much that I have seen new saws require hammering from one gumming, as already treated in hammering. It is always safe to remove all coloring where the wheel has worked. Not every time is blue case-harden, but case-harden spots are always blue; hence the necessity of running the wheel slowly and touching lightly, which will remove it all. This is understood where the wheel has worked. Some are of the opinion that if the saw is blued on the side of the tooth that it is case-hardened at that place. No matter how hot the saw should get, it cannot be case-hardened only where the wheel cuts. The work should be done uniformly, so that the saw will be in balance and all the teeth of the same pitch. A true circle should be struck at the required depth of tooth, then strike another line as shown by lines 1 and 2, 1 being the line for light power. Then with a straightedge mark the pitch as shown by the straight lines, only mark to the depth of tooth.

There will be noticed but a slight difference between *A* and *B* of Fig. 2 and of Fig. 1. *A* shows the proper tooth for mills ranging from ten to twenty-five thousand feet capacity, which shows one-half pitch. *B* shows too stiff a tooth, back being too high, though it clears as shown. This style of tooth is better adapted to frozen or hard wood. It will not stand much feed on account of its high back. Many men are of the opinion that



TEETH FOR MILLS OF MEDIUM CAPACITY.

PART II.

if the back clears well that is all-sufficient. This can be worked on light power, but not successfully on 3″ to 4″ feed. The tendency is to press against or jamb the saw. *A* being a little stiffer, will answer for hard wood. Such saws require from forty-six to sixty teeth as to feed. *C* shows the proper shape point with a good stout corner with no shoulder for friction as at *E*, which is a tooth recommended by saw makers; but it will not work well after getting a little dull, as any one of experience knows. It soon gets in the shape of *F*, which needs no further explanation. As to the width of set, I am inclined to run enough set. Many are too close in this respect and lose twenty-five per cent. of their power by friction, which makes heat, which of course makes bad lumber. Then for the saving of one sixty-fourth of an inch do not ruin your saw. A seven gauge saw should have five-sixteenth inch scant set and not over five-sixteenth inch. Hard wood a little less. An eight gauge should have nine thirty-second inch scant, with good corners. An eight gauge will run very well with one-quarter inch full; ten gauge one-quarter scant. For gumming, refer to Part I. The filing should be done perfectly square, back and front. If saw will not run right from square filing, line, and if necessary, then hammer it.

Fig. 3 shows the best tooth for our fastest mills. *D* shows a tooth with one-third pitch from the center, with a perfectly straight back. This tooth should not be over one and one-eighth inch long. Some might ask why is this tooth on the fastest saw only of the same length of the slowest feed. This is explained by the back being straight and allowing the whole space from point to point to chamber the dust. Saw with such a tooth is capable of standing eight up to ten and twelve inch feed, which calls for one hundred teeth, about as

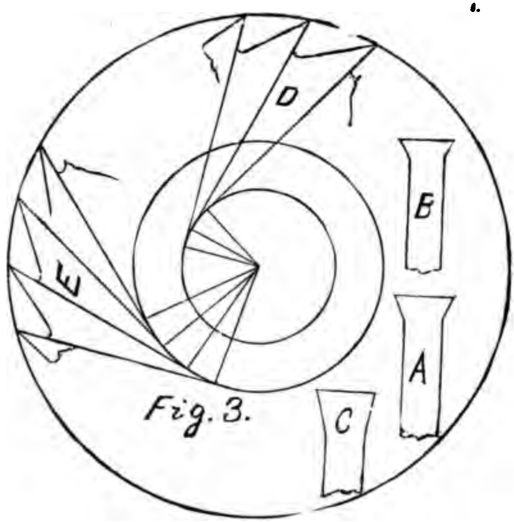


Fig. 3.

TEETH FOR MILLS OF LARGEST CAPACITY.

PART III.

many as can be put in a sixty inch saw, which is not quite up to the required number. Now, one hundred teeth in a saw like *A*, Fig. 1, would not stand the feed, and if it did, the throat would be so narrow that it would not chamber any dust. This tooth often measures but two and one-fourth inches from point to point, but will chamber a quantity of dust. The short pitch is also necessary, as a fast feed saw will not stand up well even with one-half inch pitch. This tooth has all of its resistance, or strain, directly on the front of tooth; then it is plain that the tremendous speed of log onto saw will not jamb or push against the saw, which would bulge or dish the blade from guide to center, which would throw the saw short out or in the cut, as many fast saws are noticed to do. *A* shows the proper tooth from a view of the swaging. *B* shows too slender a corner, though precisely the tooth 4, Fig 1. This tooth will crumble, as the action is to scrape instead of cutting. *C* shows a heavy tooth which will run well for a while, but will require more power, as there is considerable friction. This represents the majority of work from the swage bar. *A* is a tooth that can be had with any of the standard lever or power swages.

This saw will require considerable power to drive it, which is always, and should be, in large mills. The automatic sharpener should be used, or some of the good hand sharpeners, filing being too great a task; besides, precision is very necessary. The changing of saws four to five times a day causes the sawyer some trouble if they all do not run nearly alike. In many modern mills of to-day, power and economy of saw plate is no item. Such a tooth as *C* is necessary when but ten teeth, and sometimes a less number, cut an inch of feed. Ten inch feed with seventy teeth like *C* will do good work.

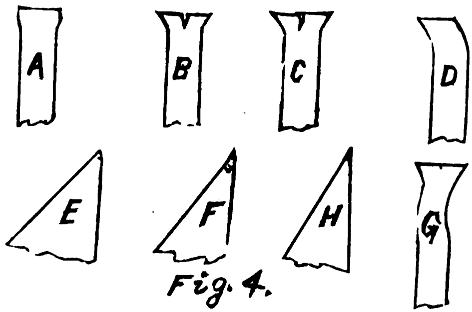


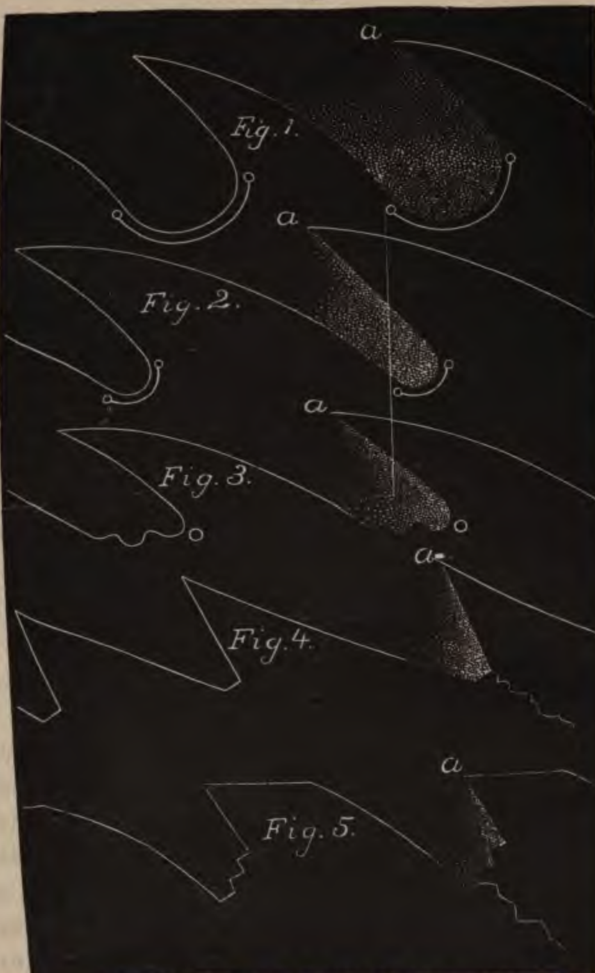
Fig. 4.

SWAGING SAWS.—IMPROPER USE OF THE SWAGE.

Fig. 4 represents various defective uses of the upset, a swage in common use. Its use when properly applied makes a good tooth for all small and medium capacity saws. *A* shows a dull tooth, which ought not to be, but should be filed to a thin edge, then it will swage well. *B* shows the result of swaging a dull or thick tooth. *C* shows a reckless "dead" blow. Often the corner will not show its defect, but the first log sawed shows a "washboard" mark. *D* shows the result of too heavy a blow on a partly sprung set. *E* shows a tooth too thick to swage, with but little accomplished. Continual pounding on a tooth of this kind crystallizes the steel. *F* shows upset not properly set, leaning too much to the operator. Such work often results in a broken point, as shown, and keeps a saw continually out of round. *H* shows how other teeth may be swaged, which requires no further explanation. *G* shows excessive blows on slim teeth, which puts a tooth in very bad shape. The upset should be used lightly with a clear ring from the hammer. A deadening sound indicates defective work.

The swage bar and hammer is a good swage when in the hands of a good user. When an automatic sharpener is used and a number of saws to be kept up, an automatic hand or power swage may be used. Such tools are good when used right, and on the contrary they ruin a tooth. No machine will do good work unless the filer knows just what good work is. A mill man who is not disposed to take hold of improvements needs no automatic swage. Only the well-up filers make a success of them.

This engraving illustrates various shapes of teeth, showing economical and wasteful use of saw plate. Fig. 1 shows the extreme waste, which is a very slim tooth for hard wood. If this tooth were fitted for soft wood it would stand the heaviest feed and not be a wasteful tooth, as its fast cutting fully compensates. Such a tooth on a small mill is wasteful and would not last half as long as tooth 2. Notice that its depth from point to throat is not more than half that of 1. Its wear



ECONOMICAL USE OF SAW PLATE.—HOW A SAW TOOTH CHAMBERS ITS DUST.

is nearer on the periphery of the saw, and not toward the center, as 1. As shown, 1 chambers twice as much dust as 2. Fig. 3 shows a tooth that will not chamber well. The irregular throat prevents clear circulation. Fig. 4 shows another wasteful tooth, good for nothing but as shown, viz.: a broken saw. Fig. 5 shows a tooth with the result of filing square corners. The tooth itself is slightly modified from a perfect saw.

INSERTED TEETH SAWS. THEIR UTILITY, CARE AND MANAGEMENT.

The inserted tooth saw is the best saw in its place. The question is, How is the mill-man to know this? Many men have failed in the business when if they had had a good inserted tooth saw would have made money. Then this subject is a matter of interest, that is, for mills of small capacity.

I will now explain the advantages of a good inserted tooth saw. Some are not worth buying. If the mill-man is sawyer, filer, engineer, yard clerk, etc., the inserted tooth is much the best saw. This is with a man who may understand fairly well about gumming and filing. The principal difference comes in the saving of time. If a mill-man's time is worth more attending to customers, belts, engine and machinery at odd times than it is to be buying emery wheels and files, losing time filing and gumming, to say nothing of saw growing smaller and requiring hammering, then there is no question about the inserted not being the best saw. In small mills from four to eight thousand capacity, I have noticed that the owner or sawyer attended very nearly to all the machinery, looking after the water. On the other hand, if mill is to be run regular and the sawyer knows his business, has an engineer, and has time to file his saw and gum it, and does it right the solid saw may be used; but then there is an inclination to favor a good inserted tooth unless mill goes above fifteen thousand capacity. The great trouble about solid tooth saws is as I have stated already. They get too many teeth in them. It is a fact that with too many teeth and light power the best man in the world could not run a saw successfully, especially in hard wood. The inserted tooth overcomes this in that the makers do not and cannot put in so many teeth. The inserted tooth requires less hammering, which is an advantage to small mills, and many inserted tooth saws are run one to two years without re-gumming or hammering. The same mill with the solid would stand a good chance of having saw not only hammered several times, but would probably have hammered into another new saw. Why? Because a man that cannot file or swage a solid saw soon ruins it. With the inserted there is some retort, viz.: put in a set of sharp teeth; hence a new saw every time. Inserted teeth saws generally are not abused half as much as the solid, and I have had many to ask why, in the same hands, this is plainly seen. With the solid saw running bad, what is done? Cannot stop and file, as saw has just been filed and swaged. That would not help the case. What is done in many cases? Saw is cooled off with water dashed on it, which only adds to its ruin. The inserted is not treated so. Why? Because swager knows that it will run with sharp teeth, and stops and puts them in. The filer might stop and file the solid, but only to make it worse. There are plenty of men running saws who know practically nothing about them. This is not saying anything against them, as it certainly could not be expected that all men could be experts. The inserted tooth for edger saws in large mills is becoming a favorite and gives good results, and maintains another important item, viz.: attains their size. Inserted teeth saws of reputable makes maintain their tension for a long while because the teeth and rings are milled to a gauge, the rim is not stretched more in one place than another by teeth not exactly the same size. If rivets or keys are used a very light blow, giving all an equal strain. Such saws are hammered as the solid, but with less tension, as centrifugal force does not act as much on them.

SHINGLE SAWS. HOW TO FILE, GUM AND HAMMER. A GREAT SAVING IN POWER AND TIMBER DEMONSTRATED.

Shingle saws generally require but little tensioning. They often get "spalted," and in such cases the rim can be brought true on the block without removing from the collar, always applying the straightedge on the upper side. It should then show a high place to be on the collar side. Considerable light will be seen under straightedge. For leveling the rim, use a short straightedge. Then use a long one clear across the saw to see if center is a little lower than the rim, say one thirty-second inch for hand machines and single cutters; but double cutters, or "blockers," require the rim to be about one-sixteenth higher than center. Straighten the saw as previously treated on large circulars, but using only a "tap" of a blow as compared to a thicker saw, or you will make saw worse. Examine closely for short twisted places, as described, and remove them with straight peine light hammer. If saw, after truing the rim and the center, should show to be a little higher, loosen the screws on outer edge of collar and insert, say one thickness of heavy writing paper, or more if necessary, uniform around the collar and screw down tightly. Should rim not revolve true, insert more paper at lowest place, or withdraw some at the highest place. What is wanted is a true rim, which can be easily had after removing the crooks or lumps between rim and collar. A shingle saw is too delicate for any but a few to attempt to hammer, because their heavy blows quickly get the saw worse. While machine is running slowly, the uneven places on the rim can be marked by holding a piece of chalk or end of broken file steady. The short marks indicate generally a sprung place which needs straightening; the parts that are not marked which show some distance require papering. But little will raise the rim. If after getting rim true it may be too high—that is, saw may run up too much—if in a double cutter saw, and the filing will not bring it right, the center screws must be removed, and small segments of paper at regular intervals inserted. Do not take saw off collar unless compelled to, as you are liable to destroy your former work by moving the paper. It is not best to have a single cutting saw stand up too high on rim, as they will cut uneven, running up in hard blocks where the grain is not straight and cutting thick shingles in very soft blocks.

Double block saws must be square with the machine in every way, that is, parallel with the ways. This can easily be done by measuring at four equal points out from the center of saw. All these points must measure the same, from saw to planed ways. All such machines have ample provision in the arrangement of the boxes.

TENSIONING SHINGLE SAWS.

As stated, such saws require but little tensioning. Very high speeded large saws sometimes require it. In such cases, saw must be taken off the collar and stretched on anvil lightly inside of screw holes. If saw is very stiff and two lines do not help it sufficiently, working on both sides of saw, work on one line just outside of screws. Where saw is bright the impression of the hammer will show a dull spot on opposite side, which will serve to apply the blows opposite each other; but if the saw is hit gently and a firm, solid blow, the saw will not be sprung. High speeded shingle saws require that the center be a little slack, but not to sag or dish. A saw that requires tensioning will flutter or clip shingles. If saw is suspected of needing tension, speed it up a little higher for a short duration, and if it clips and runs worse it is a sure indication of requiring tension. The higher speed expands the rim more, which of course makes the saw run badly, clipping the point and often cutting thick; but at same time, a saw too open will generally run down and clip, but its work will be more uniform. Such saws will heat near the center, which only makes saw that much worse.

HAMMERING SHINGLE SAW COLLARS.

Collars often get sprung through carelessness, the saw always getting it first. Excessive heat sometimes springs a collar permanently. It is not generally believed that a collar can be hammered. First apply the straightedge and locate the low place on the edge. Now directly opposite this place on the taper side of the collar, peine it with a sharp ball peine hammer. This opens the metal on this side, which concaves the opposite side. Collar should be flat on anvil with light blows, especially near edge, or it may be broken. A blunt center punch would almost answer for the purpose. There is no work at all done on the flat side of collar. Many "expert" saw hammerers advocate this theory on saws and "peck" a saw from the concave side, stretching the steel which raises the metal up—a nice way to treat a saw with its surface all cut up, with lumps as prominent as ever, with the tension so badly deranged that saw won't run. No man who hammers in this way ever knew, practically, what unequal tension was in any saw.

FILING AND GUMMING SHINGLE SAWS.

The shingle saw also gets its portion of bad filing with badly shaped teeth. In many mills there is a loss of 25 to 40 per cent. of power from bad saws, and from 10 to 15 per cent. lost in saw kerf. This may sound astonishing, but I will demonstrate how 18 gauge saws can be more successfully run than 15 gauge.

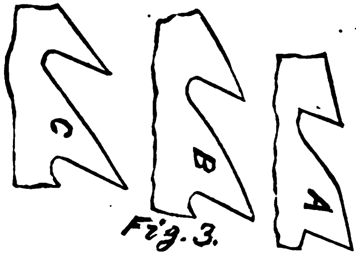


Fig. 3.

Fig. 3 shows three styles of hand feed teeth. A dozen kinds might be illustrated, but *A* gives a fair average. This tooth will pull 25 per cent. heavier than *B* and will shove the operator 50 per cent. harder, which of course is a friction on the saw, losing power. *C* shows a tooth that might be overdone, too deep and slim. This tooth will snatch the block or spalt, and will not cut smooth or even shingles; will make waves, especially in a hard block. Try tooth *B* and you will be convinced and have something that will shove easy and save your power.

Fig. 4.

Fig. 4 shows power feed teeth of shingle saws. *A* is the proper tooth. *B* is a power consumer. It will cut a fair shingle for a short while, then it will be calling for all there is in the engine or continually pulling belts in two. This tooth when a little dull, say after one and one-half hours' run, will make bad shingles. Such a tooth requires unnecessary set. It might be called a fair average tooth for many mills. *C* is a better tooth, as it is not quite so thick and has a little more pitch. *C* will tremble, which makes a rough shingle when filer was particular in having an even set. It has no free circulation for dust and will often jamb and have to be cleaned. *A* is the tooth that can be relied upon every time and in all kinds of timber. It is short, has more dust room than *B* and *C*, and will cut a smooth shingle. *A* will run with less set than the latter. In gumming shingle saws the back should be kept straight for power feed and with less pitch. Hand feed will stand more pitch with a little rounding back, as described. Care must be taken not to case-harden or to leave any on the teeth. It will strip your file and snap teeth off when setting.

LINING SHINGLE SAWS.

Double block saws are square, that is, of same distance on each side from the bottom of planed ways. Hand feed and rotary machine saws require a trifle lead in the mandrel, also a little in the saw, as indicated. Too much lead in the saw is bad in cutting broad blocks. Narrow blocks do not show it so much. For hand machines the same or a little more lead. Such saws may be flat. I have seen them a little high in center do very good work. Nothing like this would do in power machines where they are crowded for all they are worth.

THIN SAWS AND HOW SOME MILLS MAY SAVE THOUSANDS OF DOLLARS ANNUALLY.

This is a fact which I can plainly demonstrate, the satisfaction being got in testing it. Take the average of saws run on Challenor's or Perkins' double blockers. They are fourteen or fifteen gauge with eighty and ninety teeth, filed about like tooth *B*, Fig. 4. Now, such machines will run lighter, better, be lighter on belts and power, if a seventeen gauge saw with one hundred and ten teeth for 36″ saws and one hundred and twenty for 38″ saws, filed like tooth *A*, Fig. 4. The principal feature comes in the saving of timber. This may sound like folly, but "figures won't lie." Make the calculation a fourteen gauge saw will not run with less than one-eighth inch set, with but eighty to ninety teeth. Why? Because so few corners to do the work they soon get dull, not from cutting, but from friction. The standard sixteen inch shingle measures precisely one-quarter inch in center, saw kerf making three-eighths inch. To make a shingle with blocks averaging fifteen inches high, makes forty shingles. A seventeen gauge saw will run with three thirty-second inch scant set. This is giving within a fraction as much set as the fourteen gauge. When it will run with much less set in the same block, this saw will make 44 shingles against 40, a saving of ten per cent., which is ten thousand shingles saved in a day's run of one hundred thousand. To cut these figures in half makes a saving to mill men of $10 to $12 a day. The above is no experiment. I can produce evidence that I have run eighteen gauge saws on double cutters, making first-class shingles, and nineteen gauge on rotary cutters. Now, this is a consideration which should interest any mill-man's pocket. Now understand me that as I reduce the gauge of saw I add more teeth, a seventeen gauge saw with eighty to ninety teeth would not run at all. Why? The teeth being so thin would spring, which could not be helped. Thin saw condemned right there. I have seen many men make similar changes for the worse. There must not be less teeth than what I have stated. Some may advocate more power, which is not so. The thin saw calls for less power and will stand up longer, which with a great gain in shingles ought to be considered.

In many mills we see fifteen gauge seventy and eighty teeth hand machine saws. What are they doing? Changing saws six times a day for forty thousand shingles. I once put an eighteen gauge one hundred and twenty tooth saw beside one of these saws. To the surprise of all except myself, it ran lighter and stood up its quarter. A shingle saw does not take wood as a board saw and a great number of teeth will not cut a powdered dust to heat the saw, but each tooth will cut a shaving. More corners to resist the friction wear make the saw stand up, if saws are filed as I recommend, no trouble will be had with running thin saws. Apply my tooth to your present saws and note results; which will indicate whether my theory is right.

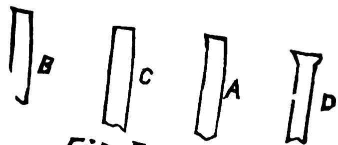


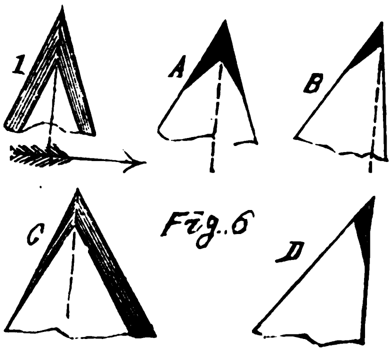
Fig. 5

FILING AND SETTING SHINGLE SAW TEETH.

C shows edge view of tooth *B* in Fig. 4. Notice how the corner is worn. This tooth will require more power to drive it than *B*. While *A* will yet run lighter; will not make quite as smooth a shingle as *B*, but will cut true and even. *D* shows a double spread. This tooth is advocated by some. I do not recommend it unless on saws of fifty to sixty teeth, as are occasionally found. Shingle saw teeth must be swaged a little occasionally and not when too dull. Some will ridicule this idea. If they prefer jointing *C* down one-eighth inch nearly and gum out again rather than swage the point it is a good thing for saw-makers.

CUT-OFF SAWS.

Such saws generally receive but little attention among saw, planing and shingle mills. As a result of this, there are many such saws broken. The front of teeth should be filed perfectly square unless teeth are very fine; then a hand saw tooth must be given.



1 shows tooth in general use with teeth straight to the center. I have seen such saws when dull changed around to cut from the other side. This tooth will not run with any satisfaction in a deep cut, as the beveling front to tooth will pass the dust jamb and heat the saw, especially in dry, hard wood. *A* shows a much better tooth; it having a square throat, will carry its dust out freely. This tooth has some pitch, as shown by dotted lines. *B* is the tooth for all purposes, places and kinds of wood. If the reader will only try it he will be wonderfully convinced. This tooth possesses many valuable points. First, it will run with less set, cut smoother, twice as easy, and run as long again without filing as tooth 1. For mitre and angle to the grain this tooth will do the work nicely. For hard wood it must not be quite so slim. There should be plenty of teeth in a cut-off saw, especially a swing saw. Too few teeth cause it to

jump, while plenty of teeth, say eighty to ninety in a fast cutting thirty-six inch saw, cannot hardly be made jump unless too little set. If *B* is a stationary saw the front of tooth may line to center of saw. The cut shows by dotted lines right pitch for swing saw. If a small swing saw with teeth one-half inch apart, square the front of teeth with a one-quarter inch emery wheel and be convinced. *C* is a man-killer. The arrow indicates the direction of motion. This shows a tooth with an extreme bevel on front and will require considerable power to drive it, and if a swing saw, there is hardly any pulling it through at all.

The advantage of *B* is that it is especially adapted for shingle blocks or heavy, deep sawing. *D* shows *B* reversed, filed square on back and flemming on the front. This is about as bad a tooth as I to pull. Try it by reversing tooth *B*, which will demonstrate results. I don't advocate new saws in this work, but a change in the present forms of teeth. Many new saws have not as good a tooth as is illustrated in Fig. 6.

BROKEN CUT-OFF SAWS.

This problem has given the saw-makers much thought. All know that square corners or case-hardened throats will crack a saw; but to say nothing of this, many saws crack even from back of tooth instead of front. This indicates the tension too tight on rim; but one says, "Not so. Saw is stiff, and how can that be?" Now, if your saw is to run at high speed, first stretch the rim close to the edge on say two lines, then saw will be very loose or open on rim. Now open half way between rim and center until saw is a little open, then it will be safe. The checking in this case is due to excessive centrifugal strain from high speed. Such saws are tensioned as the circular described previously. It is useless to explain the many shaped teeth and their result. Filing sharp corners invariably results in fracture in a high speeded saw. Cut-off saws that get much abuse should be a little slack on the rim. This allows the saw, when jammed or bent, to yield more readily, whereas a stiff saw would be more liable to break. Swing saws in saw-mills get more or less abuse and should have plenty of set.

DRAG SAWS.

Drag saws for fast cutting with fast motion want peg teeth, square on both sides, and filed like tooth *A*, Fig. 6. Slower motion saws in large logs may have every fifth tooth a drag or raker. They are hammered as crosscut saws are.

SMALL RIP AND VARIETY SAWS.

Saws used in furniture, sash, door and blind factories and planing-mills often give a great deal of trouble. Hammering such saws is precisely on the principle already treated, with the exception that small saws are kept stiff, with the exception of high speeded resaws. When such saws require tensioning in the ordinary manner, great care should be exercised to strike very light blows. Bench saws often show blue spots, which can be easily straightened back on the block. If they appear again, stretch the rim opposite such a place gently on both sides of the saw. This may make the rim too weak, causing it to heat and snake. If so, the center, except the blue spot, should be opened a little. The fence on such saws is often wrong and extends over the edge of the saw, which soon dishes the saw, and shows up one or more blue spots. The back edge of gauge should stand a trifle farther than the front edge from saw. If the front side should be farthest, the work acts as a wedge, pressing heavy against center of saw. In testing a dished saw, the center should be pressed down straight; then it will show whether it is sprung just outside of the collars, or on a line of

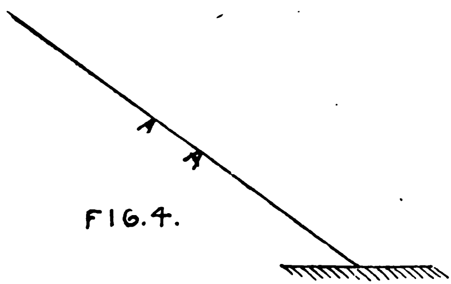


FIG. 4.

top of table. If saw gets too long on rim it will snake and should have the same treatment as given larger saws. Resaws, owing to their taper, are very difficult to get true. Some use graduated or concave straightedges, which must be applied precisely the same way every time. If center can be forced in while testing with straightedge will help in locating lumps. They should be opened near the center, owing to the friction that such saws are exposed to, which is generally half way between center and rim. If such saws were ground concave from rim to center they would run much better. The present method they are convex and sometimes straight. Small saws that are dished and many taper resaws can be readily hammered by resting saw on edge of rest, as shown in Fig. 4. With straightedge in hand, with pressure downward to bring saw straight, the lumps can easily be located. If saw was badly dished and has no blue spots it will show a high ridge at *A A*, which is just outside of collar or above table line. When saw is pressed straight its true defect is located. The filing of such saws is by far the most important.

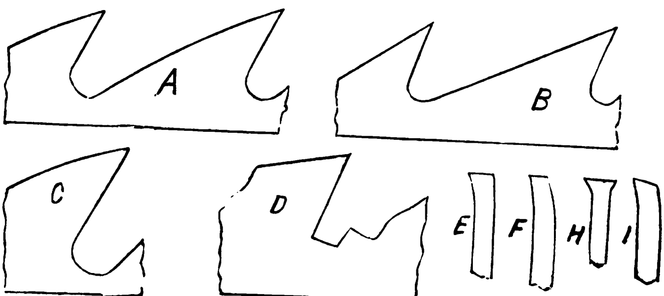


Fig. 7.

Fig. 7 shows various teeth for resaws, such as are in general use. *A*, *B* and *C* are resaw as well as rip teeth. *D* shows a modified form, which requires no explanation. *A* and *C* are considered perfect teeth by the majority of filers. *A* is a very fair tooth. *C* is a bad tooth and will make a bad running saw in hard wood. *B* is the best tooth for resaws. If the reader has any trouble with resaw and will apply tooth *B*, set as at *E*, saw will go if everything about the machine is near right. To swage such teeth helps them; in fact, all rip saw teeth that are sufficiently spaced should be swaged a little or they will become as *F*, requiring more power, hence more strain on saw, causing it to dodge, saying nothing of such a tooth tending to keep with the grain. Thin resaws can be easily run by keeping the backs of teeth down. Few realize the pressure against a saw with too high a back. Straight back with short teeth is just what is wanted. Resaws, as well as all others, can be leaded a little with the file, but should not be practiced longer than the first opportunity to thoroughly line machine and straighten or tension saw as needed. Give bench saws plenty of set and pitch.

MISCELLANEOUS.

HOT SAWS. WHAT HEATS A SAW ON THE RIM.

Mandrel out of line, with too much lead to mandrel in saw, or filing, unequal tension, causing a saw to run unsteady between guides. Too many teeth is another serious cause; having not enough set; too small a throat to chamber dust and too high a back. Too much set will sometimes heat a saw on rim. Saw not open enough for speed in its tension; too open, or large, a throat in sawing hard wood, which is the case with many inserted toothed saws.

WHAT HEATS A SAW IN THE CENTER.

Teeth not having enough set; saw too thick in center; lined too much out of the log; back of teeth too high will heat a saw in center as well as rim; too slow speed, causing saw to run from log and heating center. A hot mandrel, though it may not impart much heat to the saw, will cause a new saw to run from the log and heat in center. All this is based from a saw in good, that is, hammered to proper speed. Carriage and track out of line will heat a saw at center, the rim accommodating the vibration when center cannot. If track and carriage is not in perfect, run a little end-play in mandrel. A saw with a blue spot or full place near the eye will cause it to heat. A saw badly out of round will heat on rim.

LINING SAW WITH THE CARRIAGE.

A perfect saw on a good mill requires but little lead—just sufficient to clear the set in gigging. The ordinary rule is to give a saw one-eighth inch in twenty feet. The reader may plainly understand this method of lining. First run back block up to center of saw; force all the end-play in mandrel and carriage one way; measure the distance to saw; then back this block twenty feet, which is in front of the saw; draw a fine line just one-eighth closer to end of head block than the distance measured from saw; now move mandrel until line from center of saw will just touch or show the same opening from rim to edge.

There are many reasons why this method is not correct. First, few saws are true, and if not, the measurement is not certain. Though every saw-maker advocates this method, I will advance a way which is not governed by the saw or from any measurements from it. Run front block up to the collar; saw being off, force the end motion in carriage and mandrel apart; then measure precisely 2″ from face of collar and make a fine mark on face of head block, run the next block up and measure just the same. Now move carriage until both blocks will be about equally from the mandrel; remove saw guide, bore a 2″ hole in a piece of 1x3, three and one-half feet long or about; bore holes for lug pins, and screw it up tight on mandrel; drive a pointed nail through the end of piece to just touch the line; then move mandrel one-half over and measure the other side; move mandrel until the front edge shows a trifle closer to line; if mandrel and saw are right, then it will have the proper lead.

TRUING A SAW ON ITS MANDREL.

This I do not on general principles advocate, as the hammer is the best-known method of truing a saw. However, many may prefer this, having not the time and tools to hammer with. Not one-half of the saw mandrels are true. Then what must be done with the new saw if it does not screw up true?

Mr. J. E. Emerson recommends springing the plate by pulling it over. I have straightened slightly dished saws by pulling them over, having first heated the saw by friction on the concave side. A dished saw may be papered and brought true and run just as well. If saw leans from the log, put a ring of paper size of collar, one-half inch wide, onto the fast collar, put saw on and add several small rings to come just inside, or cut out a nick for lug pins. If loose collar is much concaved it will require several pieces of heavy paper. If saw is concave on log side reverse the paper. Sometimes a crook can be brought in much better shape by inserting segments of paper between saw and collar opposite the full side of untrue place. This can only be limited, but may be tested as often as may be desired, when saw is dished and an attempt is made to spring it straight. It should be laid off so that all the pulls will be normal, or miscellaneous pulling would spring the saw untrue.

TURNING UP SAW COLLAR.

This is something that every filer should understand. This can be done right in the mill where it runs if a little precaution is taken. First rig a perfectly steady iron rest, the top of which should be to center (one-half way the collar) with lug pins removed. Force all end motion one way with a thrust, then with a diamond point and square nose tool the operation is ready. The tools should be made of not less than five-eighths steel, with a long convenient handle, to hold perfectly steady. Run mandrel from sixty to seventy-five turns per minute and scrape off the imperfections, but by no means gouge in or attempt to take a cut. Scrape off and leave edge perfectly flat for say five-eighths, then a slight concave. Care must be used not to catch tool in pin holes directly at the stem. Care should be exercised not to leave it full. A very trifling thing will change a saw at the collars. After collar is scraped perfectly true put on the loose collar with face out; turn edge perfectly flat, say three-quarters inch, just so the remainder of the collar does not touch the saw and does not show over one sixty-fourth of an inch. Turn off the collar until the nut interferes, then the center should be scraped off. All loose motion must be out of bearings or the tool will not work well, but will chatter.

THE SAW MANDREL.

It is very essential that it be perfect. No saw can be run successfully with an imperfect, out-of-line mandrel. Where it is possible, three bearings should be used; and if pulley is overhung, the belt should be run as slack as possible with a good lap. Heavy mills are not built in this way. The bearings should be long and be self-oiling; but this is not always the case, and the present mandrel is what the reader should remedy. It should be level, with pulleys well balanced. Often the key will tilt a pulley and throw it out of balance. If mandrel is set on two sharp straightedges and leveled, its heavy side can be easily detected, and should be counteracted by adding weight on the light side. Long mandrels are objectionable and require more power. Heat in a long mandrel will make it longer and will throw the lead out of saw if collars are on outer end, as they generally are. Saw collars should be as large as possible. The average collar is about five and one-half inches when it should be six and one-half. A 64″ saw should have 7″ collar, while a 5″, as we sometimes see, will not stiffen such a saw to stand as much as one-half the feed. This is a fact; besides, small collars dish and are more liable to crack the saw at center, just outside of collar. For satisfactory results, driving belt and pulley should be as large as possible. If saws had driving pulley one-half their diameter and well balanced, there would be no trouble with slipping belts, with a twenty-five per cent. increase in the output of the mill.

A HOT SAW MANDREL.

This is a great annoyance, delay and injury to saws. There are numerous causes for a mandrel to heat, to say nothing of the many times they heat from unaccountable causes. Mandrels for log saws are often heated from grit from the log. Boxes should be protected in this way as much as possible. Cheap and dirty oil is another cause. Mandrels that heat are often out of round a little, or soon wear so. Steel is much better than iron and will wear better, yet it will not remain so in wearing. Common babbitt is another cause. Anything used that will melt and fill the ladle is too often used. Instead of ordering the very best metal, heat to a low heat that will just pour, and with mandrel and boxes warm a good job will be the result. Then redlead the mandrel, place it back, revolve it, then scrape until a perfect free fit is had with ample oil flutes cut. A mandrel that heats will be often improved by taking it up and scraping boxes out clean. Changing the lead without loosening up bolts often causes heat. The mandrel should be level and in line. Hollow mandrels are coming in use and are the best. A slow stream of water can be fed onto the saw, which is not bad on a saw. Care and good lubricants are about the best remedies. A compound of plumbago and sulphur in good oil, well mixed and applied, will help. Clean tallow is good. A mixture of soda in good oil has been known to stop mandrels when all other remedies fail; but the same application will not work every time, and what cures at one time seems to help but little at other times on the same mandrel, showing the necessity of experimenting until the right lubricants are used. New boxes and mandrels often heat for a few days. Heat in a mandrel has ruined many a new saw by dishing it. Many mandrels heat continually, and this is often omitted in ordering saws. Why? Because the heat does not bother the old saw and is not considered an item. I must say saw-makers are not close enough in that respect. A springy mandrel will heat. The majority of mandrels are too small, and bearing next to saw should be turned down nearly one-quarter inch. This reduces friction. The back end near drive pulley should not be turned quite so much to prevent springing. Any mandrel can stand to be one-quarter inch less at bearings, which will help very much. Too light and too tight a belt is another great cause. Belt should be protected from dust, so that an elastic or cohesive surface can be given belt. A little castor-oil will stick well, but a very little at a time should be used.

MILL BUILDINGS.—HOW TO BUILD.

This is a very important consideration with the mill-man, especially with the successful man. No man ever built a mill to his exact liking, there being more or less changes necessary to produce more and cheaper lumber. No one man ever knew all about building mills, but by having the opinions of others a man is often led into convenient ideas.

SMALL AND PORTABLE MILLS.

Such mills should consist of a single circular, if small timber, and a top saw if necessary, should consist of swing cut-off saw and log turner. With this machinery four men, outside of the sawyer, can cut from four to five thousand feet of good marketable lumber. Such mills should be set on a hill-side, if possible, parallel with same, so that logs can be received from the side of the mill and dropped as near as possible to carriage. Engine should be of high speed of a reputable make and run with a governor, making the work lighter on engine and machinery. A long, heavy saw mandrel should be used with at least three bearings. This gives space for stacking rough edge and allows lumber truck or car to come right up to the saw. The log turner can be driven from the saw mandrel by a quarter twist belt. The swing cut-off saw may be run from this shaft by extending it, but it is preferable to drive it from engine shaft and put it back from the saw at least five feet farther than the longest stuff that is to be sawed.

Then carriage is not shoving against it and breaking saws. With the sawyer's set lever, he and the man who rolls down logs can easily turn logs; one man behind the saw and one at the swing saw to trim, cut up slabs and take out lumber. With lumber car right up to saw, the man behind the saw loads this car as the lumber comes from the saw, the swing saw man cutting up the accumulation of slabs, etc., collected while he was taking car out. The track should be ironed and the car light with large wheels. The mill should have ample room. When edging up the rough edge (which is done on the carriage), the log man helps, and so everything progresses well for five thousand feet per day. Without the swing saw, lumber goes out in bad shape, not trimmed. An extra man is required to cut up refuse. Many mills use no log turner, necessitating an extra man, besides a decrease in the output of the mill. The sawdust should be carried out on a conveyor, which can be cheaply built from 4″ to 6″ cotton belting with cleats on the outside every five feet, and run at not over one hundred and fifty feet per minute. Small mills usually use fire-box boilers, which will not burn dust well; besides, the dust can be handled much cheaper than slabs. In arranging a mill of this kind for sawing long lengths all the posts of the mill should be on the other side of carriage, directly in center of mill, one being at the end of mill, the other not near enough the sawyer to interfere with turning logs. On these posts should be a heavy cap, then projecting joists, heavy enough not to sag. The posts on the outside of mill should be anchored, or set, deep in the ground, with joist well secure. This allows all clear in front of carriage, with no posts or suspensions. The posts and joists form a cross, the long end of "T" receiving the outside posts set far enough back that the suspended end will not sag. This is by far the cheapest plan, as it requires nice framing to put in a span, besides having to use heavy timber. The utmost care should be exercised to have good, solid foundations for machinery, and put in perfect line. This is essential in erecting any machinery.

MILLS OF MEDIUM CAPACITY.

Such mills may be set end to hill-side, especially if to cut bills on short notice, logs being brought in on a car, the track can be extended, allowing access to length and quality of logs on either side car. Track should be lowered sufficient to allow logs to roll on free. If logs are to be received from water or from an incline, a "bull" rig is necessary. But little space should be between car and carriage, and this on some incline. All the machinery except saws should be on the first floor. In a mill of ten to fifteen thousand feet per day a light four saw gang edger should be used and set a good distance from the main saw, but within two or three feet of main rolls. This allows edging long stuff, and when edger should be idle from any cause, some space is had for piling edging. Swing saw on main line rolls should be directly opposite the discharge from the edger, then the edgings and lumber to be trimmed can be easily transferred. Lumber is received directly from edger on car or trucks, as well as from main rolls. A slight incline should be on the other side of rolls for bill stuff. If straight boilers are used, the furnace should be at front end, directly opposite the saw, so that a conveyor can be used running directly over top of boilers and discharging dust through iron spouts into furnace. Slabs may be sold for wood or taken out on a light car to a burner or in safe place to burn. In this mill seven men besides the sawyer should cut ten to twelve thousand feet per day. Two or three live rolls can easily be used, driven by a 4″ belt with a depth turned in the roller; such rollers arranged on a pivot frame drop down when not needed. They are indispensable in getting out heavy timber with but few men. Such a mill, if on a portable order, need not have heavy upper framing, but lighter, and built on the lower frame. If a planer and dry-house are required and to be driven from the same engine, would advise the planer direct on ground floor; if room under the mill, on the same side of mill that landing or switch is.

Dry-house should be on the other side of mill if convenient, and may be of the smoke-kiln style, which is cheap and not expensive to run, as the surplus slabs will make the fuel. Lumber for kiln should be taken on lumber trucks, while a light car and track should lead from kiln to planer. Every mill should have a dry-kiln and planer. The kiln will dry the stock, be dressed and paid for long before air drying sets in. Most every one is familiar with the old style smoke-kiln. The lumber is stacked some distance from the ground, with a long, deep trench under each pile for receiving the fire. The portable roof and end being placed in, a slow fire is kept up. A wire gauge or screen is often stretched between fire and lumber to prevent sparks from igniting. One man can take care of one-half dozen of these kilns, which will dry four to five thousand feet per day. The track to planer should run parallel with kilns, which often requires a turn-table before reaching planer conveniently. If mill is built on the ground, planer may be set behind, the carriage track parallel with same, with counter-shaft from engine overhead. All planers should have a good exhaust fan for conveying shavings either to furnace or to a burner. It is the best plan to have planing-mill separate, driven by separate engine; but there are many small mills which cannot afford this extra outlay for a small amount of dressing.

MODERN MILLS OF GREATER CAPACITY.

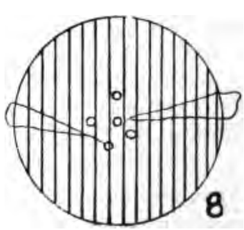
In building such mills, every precaution should be taken for convenience and cheapness of manufacture. One defect or badly arranged machine or part of machine will throw a fast mill out of ten thousand feet per day.

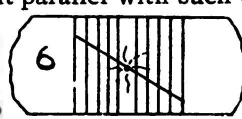
The arrangement of boiler and engine need not be discussed farther than that they should be detached from the saw-mill, and in a fire-proof building; then the burning of the saw-mill will save engine and boilers. Logs should be delivered to mill by an endless chain with toothed dogs for hauling up logs. An endless cable with car may be used with a friction grip. This allows car to be moved at will, while cable runs continuously. Automatic stops are often placed in log deck, by which logs stop themselves; then with a steam "wench" they are delivered to steam stop and roller, from which the steam nigger places on the carriage and is ready for sawing. Edger should be placed a good distance from main saw and as close to main rolls as possible, leaving about two feet. Live rolls should be from seventy-five to one hundred and fifty feet long, and in from two to three sections, each section speeded faster nearer end of run. Nothing but bill lumber should pass edger. Everything, as near as possible, should go through edger, then to trimmer, assorted and carried to destination on conveyors or lumber trucks. An edging cutter should be placed aft the edger next to live rolls, delivering same into a conveyor that should run the whole length under the mill. This could deliver, if necessary, into a cross conveyor to burner. In the second section of live rolls should be a blind saw for cutting long rough edges or sidings. This section should have independent rolls, reversible, then the edger could take care of all long or medium stuff. Sawdust conveyors should run parallel with trimmer, taking dust from same and from the edger, delivering into burner or to conveyor to furnace. Conveyors should be so arranged as to keep mill clean. This is too often overlooked, and the result is, mill and premises are soon blockaded with trash. For convenience and cheapness, everything should go directly out from main saw. Handling lumber sideways in a mill does not pay. Some mills are arranged with a steam transfer to edger, edgers being set far enough from main rolls that trimmer may be placed between it and main rolls, with a lumber conveyor running parallel with rolls. All lumber from trimmer and main saws for stock or kiln go out by this conveyor. Bill stuff is dumped from rolls at the desired place by means of friction canters. Bill lumber from edger instead of dumping into conveyor is passed over to main rolls, then out. This style of mill is coming into general use, requiring but few men to handle an out-put of seventy-five to one hundred thousand feet per day of heavy lumber. Double circular and gang mills have gang placed from fifty to seventy-five feet from saws, with steam canters and transfers by which every cant is placed direct on rolls in front of gang without a hand touching it. These remarks are to form but an idea of the arrangement of mills. It will pay anyone contemplating erecting a mill of expense and of modern capacity to travel around and see what is going on. No two mills can hardly be found built alike. Many good mill-men pay their profits out in expensive manufacture. The idea is to arrange to save labor by doing the work with good, well-arranged machinery. Saw-mill machinery should be much heavier, that is, of greater capacity than intended; then breakdowns and worn-out machinery will be avoided. Heavy shafting, with light, broad-faced, well-balanced pulleys and heavy, broad belts should be used, but not too long. If possible, avoid tighteners. Good, broad belts, after stretching, will do their work without rattling tighteners to sooner or later automatically shift belt and ruin one edge. An erroneous idea among many is to have heavy, large-diameter pulleys to deliver to machines "getting speed." This is a mistake. The driving pulley should not be more than two-thirds larger than driven, else there will be but little belt contact. As stated, a high speed engine (if not the Corliss type) should be used, and every pulley from it to the machine be as light as possible. Belts in saw-mills suffer great abuse from dust, it being almost impossible to prevent it. Dust chafes the rubber from rubber belts, besides causing them to slip. Endless leather belts are preferable, but must be of an extra quality to give satisfaction. Poor belting is the worst element to a saw-mill. The successful mill-man, that is, he who has started with little and come up to the modern mill, spares no pains in selecting the very best machinery of ample capacity, set on good foundations, with heavy mill frame. Vibration to machinery remains only a question of time to ruin it. Any unbalanced pulley should at once be balanced, or a new one replaced. True, smooth, heavy and well-lined shafting, with bearings protected from dust, will run for years with but little wear or attention, farther than prompt oiling. Light shafting with unbalanced pulleys, narrow, tight belts, are: First, hot bearings, shaft getting out of line, eventually a broken shaft, to say nothing of continual annoyance. Put in the best.

HOW TO SAW CHOICE LOGS TO BEST ADVANTAGE.

WHAT CAUSES SPRINGY LUMBER.

Sawing a log to best advantage is a very important item in any mill. More lumber is saved in this way than in all the thin saw theories. Among fast mills with small logs but little, if any, time can be consumed in setting, log quantity being the aim. In the average and small mills much can be saved in quality and quantity of lumber. It is no common thing to see joists and square stuff badly sprung from defective setting of the log. No log should be sawed directly through the heart, as the lumber will spring. The heart should be enclosed, which is done by sawing all around it. The heart, or center, of no log looks well; so in sawing inch stuff the heart should be left as near as possible in the center of a 2″ or 3″ piece, as necessary, which encloses a defect in appearance. This is the only way to saw oak. In sawing oak do not saw past the heart, as it will spring badly. Straight trees in pine, hemlock and large cypress, spring but little, unless the heart is on one side of the center, and log is oblong, not round. This indicates a leaning tree. The underside will pinch a saw and spring badly. This side always shows a much coarser and darker grain. The saw should cut parallel with such defects.





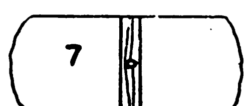


Fig. 8 shows reckless setting of a knotty log. Almost every board will be more or less affected. Had it been turned on carriage with knots parallel with saw, lumber would have been fifty per cent. better, as the center piece would have taken in the knots, making one or two merchantable boards. Often clear logs have but one or two knots, as at 8. Care should be taken to set log right if clear lumber is worth anything. 6 shows reckless setting against a defect. nearly all the ten boards shown being defective. Though if split but little, are defective for two feet, which alone is a considerable loss in clear lumber, to say nothing of the shake extending from end to end as in many logs. 7 shows how log should have been set. Oak logs should be sawed as soon as cut, or they will check badly. Painting the ends with a heavy coat of red or white lead will prevent season checks. In white oak the best second growth timber, which is decidedly the most valuable, is more susceptible of checks and springings after being sawed, which in small, young trees can hardly be avoided. Such lumber must be put on sticks right away. If allowed to season in a crooked state, only steaming will bring it back. In sawing choice, broad lumber, it should be all edged on the edger, the log set with its best sides to come parallel with the saw, either from the first sawing or after being turned down. If 7 was a clear log for broad boards it should be set so as to saw it parallel with the crack, sawing half way, then turning to the knees and leaving a one or two inch piece, as desired. 8 illustrates a log with considerable clear lumber had it been sawed the other way, that is, parallel with the knots. It is common to find one or two large knots on large logs, especially near the top of the tree. Pine and all its species have the knots extending clear to the heart; not bumps or snarls which will be sawed out in one or two boards after the slab. Such places must not be considered as knots. Knots are where a limb was once, and can generally be easily detected. Oak is of a different nature, and all defects that show on outside generally get worse near the center.

SAWING CROOKED LOGS.

It is not generally known that straight lumber can be sawed from a crooked log; but it is a fact. Carpenters often have much trouble with sprung scantling and joists, due principally to defective or reckless setting of crooked logs or logs from a leaning tree. The latter are often straight logs but make springy lumber.

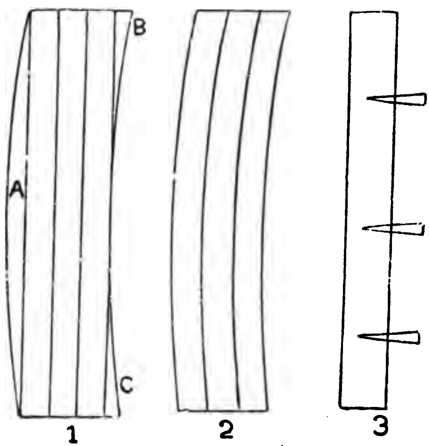


Fig. 2.

No log is so crooked that it has not two sides much straighter. If scantling are to be made from a crooked log on an edger, it should be set on the carriage so that the edger saws will take the stuff the straightest way of the log, and not as shown at 1, Fig. 2, which shows the stuff cut the crooked way. 2 shows the shape the scantling will assume in many cases. They will "bow," pinching and heating the saws. *A*, *B* and *C* show considerable waste of timber. If log is to be turned but once, and that to the knee, sawing half way, it should be set with the bow, or belly, to the saw or to the knee, which is about the only way a crooked log could be set; then the boards or scantling, as may be, will come out straight sawed and not spring from the edges. If scantling are to be cut on the big saw, the same precaution is necessary. 3 shows what many mechanics have to do to straighten studding and badly sprung joists and rafters to make a neat job. It shows the concave side sawed into and wedged open to straighten. The smaller the stuff is cut from a crooked log, the more it is liable to spring. Two or three by twelve and inch plank come out generally straight; but if calculated for resawing on the edger into three, four or six-inch strips care must be exercised as stated.

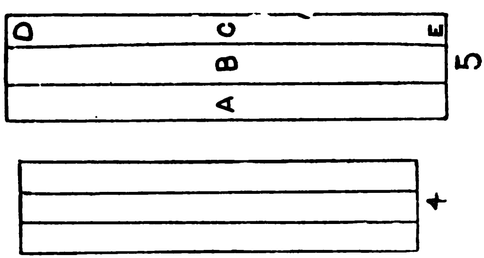


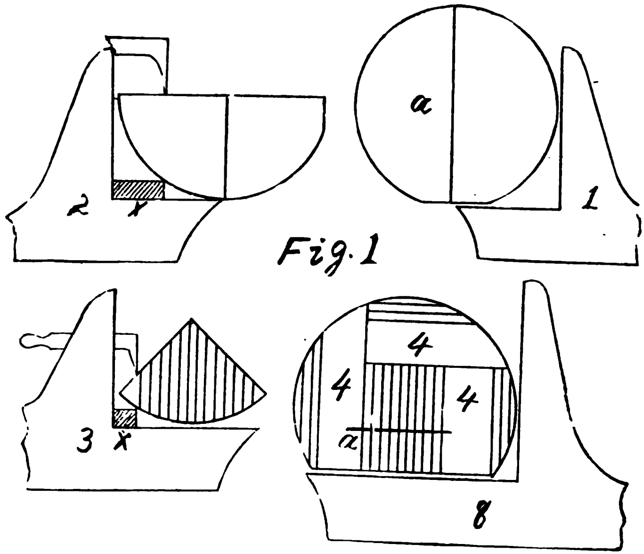
Fig. 3.

Fig. 3. 5 shows a crooked log dimensioned on the big saw for 4 or 6-inch stuff. This log shows to be "fletched" or ripped precisely as at 1 in Fig. 2. This log will pinch the saw badly and cause it to run a little crooked; but more often it is the timber sprung

before the saw gets through. *A* shows the first line run true. The next line, between *B* and *C*, is badly sprung, showing to be much wider at *B* and narrower at *C*, with ends at *D* and *E* of proper width. All sawyers have noticed in ripping a crooked log that the second line is generally the worst, while the first line pinches worse. As stated, a log from a leaning tree can be easily detected, that is, when the heart is much from the center. If deals are to be sawed for the edger, the log should be set so that the stuff will be cut parallel with the oblong side of the log. In other words, the heart should be set nearest the saw or to the knee, sawing the deals off while in this position. If log is attempted to be ripped in this way on big saw, the big side that shows the coarsest grain will pinch badly. Some logs will pinch and lumber be a little crooked when sawed by the above instructions, but seldom. The plan is laid down. Any man can convince himself on but one crooked log.

QUARTER-SAWING.

Quarter-sawing, which is sawing the log as near as possible from bark to center, makes very valuable lumber as a finish, and in ornamental furniture and cabinet work. The various kinds of oak, ash, gum and sycamore are the woods principally used. For flooring pine is quarter-sawed, but in a different way from the above woods. When this lumber is in demand, any class of mill in good order can reap the benefits of their logs by quarter-sawing them. The principal and only economical way is to first halve the log, as shown in cut Fig. 1 at 1. A light slab is first taken off, as shown, that log may lay firm. Then rip it near the center, laying piece *A* off on skidway. Turn the half on the carriage down as at 2, quartering it and using a wedge at *X*, so that log will not



roll, unless an under-dog is used. It is not at all necessary to use an under or duplex dog in cutting quarter stuff. Two or three size long wedges slipped in parallel with log, until firm to log and against knee. Then insert dog at top and it is held more firm than many of the awkward under-dogs will. This half being quartered, place it on carriage as at 3, sawing it up as shown. This is the only profitable way to quarter-saw. Some recommend sawing into eighths, which loses considerable time in turning and placing the stuff on the carriage.

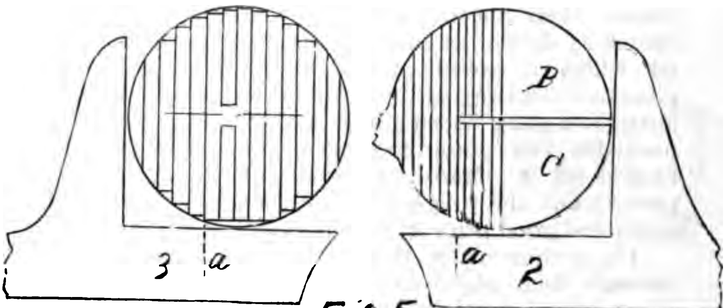


Fig. 5.

Fig. 5. 2 shows how to quarter-saw a defective log—very often a log with a large knot or other defect on one side. This is shown in the cut, and shows how the log is sawed until near the center, then the quarters *B* and *C* are sawed as described. Line *A*, cut 2, shows that several of the boards near center are quarter-sawed and may be edged. Cut 3 shows another way of quarter-sawing oak, especially if the lumber from the side of log is in demand. For other purposes fifty per cent. of this log will be quarter-sawed; and it is a good plan to saw oak in this way. Log will cut much better, saw run truer, and will turn out fifty per cent. more in quantity than by halving and quartering the log. A mill must have a gang-edger to saw through the log in this way.

QUARTER-SAWING FLOORING.

Quarter or edge grain flooring commands from $3 to $5 more per thousand than the ordinary "bastard" sawed. Large mills have expensive machinery especially for this purpose. The log is slabbed, one or two boards cut off, then a 4″ piece. Log is then turned down as in Fig. 8, a slab, one or two boards as shown, then another 4″ piece. The log is again turned as shown, leaving a certain dimension in center which, if sawed into boards, will make several pieces of flooring, as at *A*. The 4″ pieces are transferred to a gang flooring machine. Small mills can as profitably saw grain flooring as mills especially arranged for it. Many of these mills do not have a planer; but the rough product, thoroughly dry, will command good price in any market.

Fig. 3 shows how the log is sawed through and through, then edged to suitable widths. The center of log, where defective, can be made into strips six inches wide and up, making good common stock. Sawing in this way, the log is slabbed lightly, then turned down and sawed as far past the center as possible. All that part near the center will be grain sawed, while fully seventy-five per cent. of the log will be suitable for quarter flooring, there being only a board or two next to the slab that is "bastard" or parallel to the grain.

There are many mills cutting the finest timber there is into an inferior quality, when they can realize from $1.50 to $3.00 more per thousand in the rough, besides increasing capacity of mill fully twenty per cent.

STACKING OR PILING VALUABLE LUMBER TO PREVENT WARPING.

Any kind of lumber will warp if not stacked up. The sooner this is done after it is sawed the better for the lumber. Lumber sawed on a radius, as quarter oak, etc., warps and shrinks less than when sawed parallel to the heart. Quarter-sawed oak, green ash and sycamore should be immediately piled. The foundation of stack should be about eighteen inches high and inclining about fifteen degrees, as shown in Fig. 9.

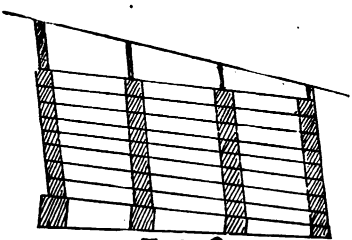


Fig. 9.

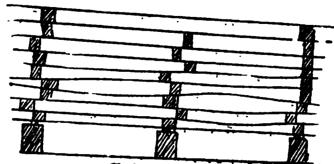


Fig. 10.

The sticks should be one inch square and very dry, and sticked exactly as shown in cut, as any lumber should be stacked. The space between boards should be one inch or more for oak and stack not wide. The sticks are placed directly at the end; this prevents end checks, which are very destructive. Oak, gum, etc., should be sticked every 24 inches. Sticks should be directly over each other, or a little gaining as to leaning of stack. Then lumber will not be sprung as shown in Fig. 10, which is ruinous. Fig. 9 shows a stack covered. By placing the sticks at end, rain cannot wet and expose the ends as in Fig. 10. Fig. 10 shows a flat covering, which has no slant, doing but little good. Sticks are not placed directly over each other, which shows the result from springing. The ends of lumber in Fig. 10 will check; being exposed, will dry quicker. If the sticks are put directly at the end, it is protected, besides having the weight of the stack as a pressure, thus preventing check. Gum should be sticked every 18″, with great care that sticks are directly over each other or with the incline of the stack as Fig. 9. Quartered lumber should be edged, and as stated, put on sticks immediately.

LUMBER INSPECTION.

HOW TO GRADE AND CLASSIFY ALL KINDS FOR MARKET.

Lumber is becoming too valuable to be sawed as often termed "mill run" or "log through." The good compensating for the bad, it not being considered that the good is selling almost at the price of the merchantable, and that one good clear board is worth more than a half dozen culls.

The most successful merchant is the man who has his goods well classified, having the good and the bad separate, and telling a man just what he is getting and by paying more or less he can get an article in proportion. The lumber business is conducted just that way with the successful competitive lumberman. No man can now embark in the business without sharp competition. I will here give the lumber and inspection rules which are general throughout the country, and can be relied on:

Inasmuch as no two pieces of lumber are exactly alike, it is impossible to make an arbitrary rule which will govern each and every piece.

A board may be perfect in all respects for a certain line of work, and still be imperfect for other uses where some particular quality is necessary. There are many considerations which enter into the proper and judicious assorting and grading of lumber which must be determined according to judgment and experience which the timber or the size is applicable, without wasting more than one-half, are *mill culls.*

Pieces of lumber that have augur-holes near the end, should be measured for length between the holes, and what is so measured to be classed in its proper quality; if any augur-holes in the center, as well as at the ends, should go into cull to be measured full.

Merchantable includes only sound lumber, free from rot, shake and unsound hearts; hearts in nearly all varieties of lumber are to be excluded from all grades above culls.

When lumber is sold as merchantable, it must be measured so as to make due allowance for defects. The rule herein given as to width and thickness is the standard width and thickness for merchantable lumber of each grade. But when some slight deviation, either in width or thickness, should occur by accidental manufacture, so long as it will not hinder the lumber from being used for the purpose for which it is intended, such lumber should not be reduced in grade on account of such deviation.

The wider the board the more latitude is allowed for defects. This remark applies generally to lengths, widths and thicknesses, although, as a rule, unless a board holds plumb to an intended thickness, it is measured to the next standard below. In dimension or bill stuff, such as joist, scantling or timber, a variance in thickness is almost universally allowed by dealers and consumers, although strict rules of inspection demand full sizes in all respects.

Manufacture should be taken into consideration in all qualities, and if badly manufactured, will reduce the grade. This is an important item, and all lumber for a competitive market should be especially well sawed. Many men are for quantity ahead of quality. Many mill-men receive a higher price than the market quotation simply because they are particular as to well sawing and grading. Remember, it takes good, that is, well lined, plumb, well balanced machinery and a perfect saw; then quantity and quality come together. The greatest drawback among small mills is for them to realize that their machinery is not in good order. They draw their observation from those who are no better off than themselves. Another great drawback is not adhering to the market inspection and grading. Lumber should be sawed and classed just as the market wants it, and not sending such stuff as suited a particular party. Few mill-men know that any log has from two to four (as the class may be) grades of lumber. Often one or two boards will bring as much as the whole log sawed into "merchantable" or "mill run." In many places the inspection and grading is not so close as in the following; but it will be much better to assume the higher degree of inspection, then draw down to the requirements or such as the market desires. In large competitive cities lumber must be as required:

Inspectors of lumber are not manufacturers and must measure and inspect lumber as they find it, of full length and width (except as to wane, which must be measured out or inspected in a lower grade), making no allowance for the purpose of raising grade unless so instructed by the buyer and seller.

In hardwood inspection the inspector is instructed to use his best judgment, based upon the rules for his guidance.

The standard knot shall not exceed 1¼ inches in diameter, and must be of a sound character.

Splits are always more or less damage to a piece of lumber. An allowance must be made, either in determining the quality or quantity, according to the nature of the split. A split extending to exceed one foot will reduce it to one grade lower.

All lumber should be sawed plump thickness. Thin lumber is not considered marketable, and must be reduced to the next standard thickness, or at least one grade lower on account of thinness.

A cull which will not work one-half of its size without waste, is a mill cull of no recognized value.

When lumber or timber does not come up to grade or contract, it must be placed in the next lower grade named.

Lumber sawed for specific purposes, such as axles, bolsters, tongues, reaches, newels, balusters, squares, etc., must be inspected with a view to the adaptability of the piece for the intended use, as, in many cases, it cannot be used for other purposes.

In inspecting the grade of firsts and seconds, an undue predominance of seconds should always be judiciously ascertained, as the purchaser is entitled to the full average in grade, which must not comprise more than 66⅔ per cent. of seconds.

Standard lengths are always recognized as being 12, 14 and 16 feet. Shorter than 12 and longer than 16 feet does not come within the range of standard. In black walnut and cherry an exception is made, and 10 feet is recognized as a standard length. Shorter or longer than standard lengths, in all varieties of hardwood lumber, except in counter tops, are to be reduced one grade lower, unless otherwise agreed between buyer and seller.

Mixed lots, containing boards, planks, flooring, bolsters, reaches, etc., shall be measured and inspected according to the rules governing the measurement and inspection of boards and planks, unless otherwise agreed between buyer and seller.

Flooring strips should be 4 and 6 inches in width; 1 and 1¼ inches in thickness. Other widths and thicknesses shall be designated as special sizes. It must have one face and two edges clear.

Common flooring strips shall be of the same size and general character as clear, but may have two small sound knots not exceeding three-fourths of an inch in diameter, or a small amount of wane on one edge which will not injure it for working to its full size.

Hickory should never be cut while the sap is rising, as it is then liable to powder-post, and indications of deterioration of this character should be carefully scrutinized.

Newels from all kinds of timber must be clear and free from heart, to square 5, 6, 7, 8, 9 and 10 inches plump. The length must be 4 feet full or multiples thereof.

Balusters and table legs shall be clear and square, 2x2, 2½x2½, 3x3 and 4x4, 32 inches long.

Newels, balusters and table legs not coming up to the grade of clear shall be classed as cull.

Counter tops shall be 12 feet and over long, 1, 1¼ and 1½ inches thick, and must be strictly clear, not less than 20 inches wide.

Clear lumber shall be 10 inches wide and over, free from all defects of every kind or nature.

Bolsters must be 4 feet, 4 feet 6 inches, or multiples thereof, in length, and the size must be 3x4, 3½x4½, 3½x5 or 4x5 inches.

Reaches must be 2x4, or 2¼x4½ inches, and the lengths 8, 10, 12 and 16 feet.

Harrow timber must be 2½x2½ inches, and the lengths 5, 10 and 14 feet.

Hickory axles must clear, and in lengths of 6 or 12 feet for sizes 3½x4½, 4x5, 4x6 and 4½x6, and 7 or 14 feet for 5x6 and 5x7 on special order, cut from sound, tough, butt logs.

Wagon tongues must be clear and straight, 2x4 at small end, and 4x4 at the butt end, or 2½x4½ at small end and 4½x4½ at butt ends, 12 feet long, from tough, straight-grained timber.

Bolsters, reaches, harrow timber, hickory axles and wagon tongues not up to the grade of clear will be classed as cull.

Standard thickness shall be 1, 1¼, 1½, 2, 2½, 3 and 4 inches, except poplar, which will allow ⅝ inch.

When lumber is sold on the market to be measured merchantable, the inspector must measure full, except in culls which are to be measured at one-half.

It is important that all lumber should be parallel in width, square-edged, and with square ends. Tapering lumber should be measured at the small end. Ordinary season checks are not considered defects.

Squares shall be 4x4, 5x5, 6x6, 7x7 and 8x8 inches.

Stains, specks, hearts, shakes, rot, wormholes, etc., are considered serious defects, reducing lumber to grades lower than firsts and seconds.

Log-run is always understood to be the unpicked run of the logs—mill culls out.

SOUTHERN OR YELLOW PINE.

Inspection grades consist of firsts and seconds, common and cull.

Firsts and seconds must be 8 inches wide and over (except flooring), free from defects except narrow bright sap on the face side, or two small sound knots not over three-fourths of an inch in diameter.

Common shall include all lumber not up to the grade of firsts and seconds, but free from shakes, large knots, or unsound lumber.

Cull shall comprise all widths and sizes below the description of common.

Firsts and seconds clear flooring and strips must be free from all defects except bright sap, which is allowable. Blue sap is excluded.

Common flooring and strips must be of the same size and general character as firsts and seconds clear, but may have two or three small sound knots of not more than three-fourths of an inch in diameter, or a small wane on one edge which will not injure it for working to its full size.

Step plank, firsts and seconds clear, must not be less than 12 inches wide, 1½ and 2 inches thick; free from all defects on one side, except two inches of bright sap.

Grain, *riff*, or *edge sawed flooring* is graded as follows: Clear and firsts.

Clear is 4 inches wide, free from all defects and must show three-fourths inch edge grain; that is, grain may vary to an angle of 45 degrees.

Firsts will admit of one or two small, sound knots, no "bastard" grain, and one-half bright sap.

WHITE PINE.

First Clear shall be not less than twelve inches in width, and no imperfections allowed unless fourteen inches wide or upwards; will then allow imperfections equal to sap, one inch on one side, extending the whole length of the piece, on pieces fourteen inches wide and well manufactured, but the face side must be perfect; as width increases will allow larger imperfections in proportion to the width, but not imperfections enough to decrease the value below the above described piece.

Clear or "uppers" are 1, 1¼, 1½ and 2 inches thick.

Second Clear shall be not less than ten inches wide, and perfect up to eleven inches in width; will then allow imperfections equal to *sap*, one inch on one side of the whole length of the piece, if well manufactured; as width increases will allow other or larger imperfections in proportion to the width, but not imperfections enough to decrease the value below the above described piece.

Third clear shall be not less than nine inches in width, and perfect up to ten inches; will then allow imperfections equal to *sap*, one inch on one side of the whole length of the piece if well manufactured. The imperfections in this quality shall not exceed *one hundred per cent.* over those allowed in *second clear.*

Select shall include all lumber of poorer quality than *third clear*, the imperfections of which shall not exceed *one hundred per cent.* over those allowed in *third clear.*

Clear Flooring shall be one inch thick, six inches wide, and no imperfections.

Second Pine Flooring shall be in thickness and width same as *clear flooring*, and will allow of one small *knot* or *sap* three quarters (3/4) of an inch on one side, with clear face.

Common Flooring shall be of the width and thickness of *first and second clear flooring*, and may have three small sound *knots*, with *sap* one inch on one side, but if less than three *knots* then *sap* equal to two inches on one side, and shall be free from rot, splits and shakes.

Four-inch flooring strips, equal in quality to *first and second clear flooring*, shall be classed as *common* six-inch flooring.

Common Pine Lumber includes all boards, plank, joists, scantling, timber, fencing and four-inch strips, that are of a generally sound character, well manufactured, and not included in the foregoing qualities. Boards and planks should be square edged, full thickness, and have no large loose *knots* or bad *shakes.* In wide boards, twelve inches and over, will allow a straight split one-sixth (1/6) the length of the piece, when otherwise sound. Fencing should be of good, sound character—pieces that will not break easily, six inches wide and one inch thick. Scantling joists and timber should not have imperfections that would weaken the piece so that it cannot be used for substantial building purposes; and uniform in width and thickness. Lumber should be measured at the small end, and, if much wane on the piece, reasonable allowance made for it.

Norway pine lumber shall be classed as *common* lumber.

Cargoes of piece stuff or timber containing over twenty-five per cent. Norway shall not be considered standard, and all edge boards and inch lumber in cargoes of piece stuff, shall be subject to special agreement.

All badly stained white pine lumber that is otherwise better than common, shall be inspected into a lower grade than when bright and free from stain.

All Lumber described in the foregoing Rules of Inspection shall not be less than one inch in thickness and not less than twelve feet long.

CULLS.

Any quality that be received in the foregoing of even lengths of 10 feet and upwards and so imperfect as to be unfit for ordinary use without waste.

CYPRESS.

Boards and plank should be in lengths of 12, 14 and 16 feet; 1, 1¼, 1½, 2, 2½, 3, 3½ and 4 inches thick. Is inspected the same as poplar.

Shakes and pecks are always a damage in cypress, and should be closely scrutinized.

Strips must be 12, 14 and 16 feet long, 1 inch in thickness, and 6 inches wide, unless otherwise ordered. They are inspected firsts, seconds and culls. Firsts must be strictly clear. Seconds will admit of one small sound knot, or, in absence of knot, may be one-half sap on the sap side. Culls—all unsound strips available one-half.

Cypress is daily becoming more popular, and is used for a variety of purposes for both inside and outside work. For house gutters and conductors it is the best possible wood to be obtained, as water has but little effect upon it, and it is equally as well adapted to general outside finish, while not a few have used it for interior molding, and also for flooring.

SKILL VERSUS SLIPSHOD METHODS OF MANUFACTURE.

Manufacturers of hardwood for shipment to any of the larger markets are engaged in a business which requires an especial degree of skill and care to make it successful. No slipshod haphazard methods will make them any money. If mills are allowed to run as incompetent or careless employees may be pleased to guide them, the output cannot be expected to show the best possible results that the quality of the raw material will admit of producing. Poor work in the mill, will, of necessity, turn out badly manufactured lumber, and when the inspector comes to put his rule upon it the effect will be not at all to the shipper's liking. Bad sawing has been responsible for more disputes between sellers and buyers than has ever the natural defects of the timber, and three-quarters of these quarrels might have been avoided if the manufacturer had exercised reasonable care in operating his mill. It is proper to do all work well, simply because it is right; but there is a more practical reason for sawing lumber just as nearly perfect as the mill can be made to turn it out. It pays; and it does not pay to do it in any other way. It needs no argument to prove that well-manufactured stock sells more readily and brings a better price than stock that is uneven in width and thickness. Any one who has ever put lumber on the market ought to know this by experience, though the quantity of stock that comes forward from the mills so wretchedly cut as to be unfit for the uses to which it should be best adapted, might warrant the belief that millmen had no object in view save to slash up logs without regard to what they make. Those who cut lumber in this fashion rarely make any money out of their work. They stand the losses, and their more careful and capable competitors reap the rewards.

There is no part of the business that can be safely left to take care of itself. Even after the lumber is properly sawed and ready for market, the wise shipper will have it loaded into cars under his own eye. Experienced dealers in hardwood say they can easily make one car look twenty per cent. better than another, containing precisely the same stock, and the same proportion of grades, by the manner of loading it. A good deal of lumber, sent into market to be sold, is bought merely upon such an examination as the buyer can make of it in the car. It is not difficult to so load it that, with a good percentage of culls, it will appear to be nearly all firsts and seconds, and not by any means a hard matter, on the other hand, to make it look like a cull carload all through. The larger mills have nearly all these things reduced to a science, and the result is that they usually make money. Smaller manufacturers would do well to imitate them in this respect; it is certainly more important, if anything, that they should save every penny there is in their product, and make every turn of their wheels count to its fullest extent in swelling their credit entries to profit and loss.

COTTONWOOD.

GRADES—FIRSTS, SECONDS AND CULLS.

Firsts to be 8 inches and over in width.

8 to 11 inches wide shall be clear.

12 to 15 inches wide will admit one standard knot showing only on one side.

16 to 20 inches wide will admit two standard knots showing only on one side.

Live white sap allowed.

Seconds are to be 6 inches and over in width.

6 and 7 inches wide shall be clear.
8 to 12 inches wide will admit one standard knot.
13 to 15 inches wide will admit two standard knots.
16 to 20 inches wide will admit three standard knots

Live white sap allowed.

Culls include all lumber not equal to the grade of *seconds*, one-half of each piece being merchantable.

Other than as above stated shall be classed as *mill culls*.

THE CARE OF HARDWOOD LUMBER.

Every mill-man desires to obtain the highest market price for the stock he manufactures, and yet lumber arrives in market daily which does not command such prices, not on account of its being poorly manufactured, but for the simple reason of its having been badly piled.

The acids of hardwoods are strong, and when two fresh-cut boards or planks are piled face to face, a souring molding, or darkening process, begins at once. This stain cannot be removed, and becomes intensified by age.

First of all, paint the ends of logs with paint containing one pound of salt to each gallon of paint. Pile the lumber the same day it is sawed, placing the cross sticks about two feet apart, and directly over each other.

It is the custom of many to use wide boards or plank for cross sticks, one at each end and one in the center of the pile. The result is that every board or plank is stained, rotten, or doty at the point of contact with these wide ratlines. Cross sticks should never be more than 2 inches wide and thoroughly dry.

Another reason for the concessions in price is often made on hardwoods when it reaches the market is that in cross sticking lumber with wide long stock, the same as that in the pile, it necessitates a pile to be 12, 14 or 16 feet wide. Such a pile cannot be well ventilated; as a consequence, much of the lumber in the center becomes streaked and browned in the hot months by the gaseous vapors which have evaporated from the lumber during the day, and settled back upon it during the night.

BLACK WALNUT.

The inspection grades shall consist of firsts and seconds, common, and cull.

Firsts and seconds must be six inches wide and over. At 8 inches one inch of sap or one standard knot, and at 10 inches two inches of sap or two standard knots may be allowed. An allowance for more defects of this character may be made in proportion to increased width.

Common shall be 5 inches and over wide and shall include all lumber not up to the grade of firsts and seconds, but available full three-fourths of its size without waste, free from hearts and unsound lumber.

Cull shall comprise all widths and sizes below the description of common.

CHERRY.

The inspection grades shall consist of firsts and seconds, common, and cull.

Firsts and seconds must be 6 inches wide and over. At 8 inches may have one inch of sap or one standard knot, and at 10 inches two inches of sap or two standard knots. An allowance for more defects of this character may be made in proportion to increased width.

Common shall be 5 inches and over wide and shall include all lumber not up to the grade of firsts and seconds, but available full three-fourths of its size for use without waste, free from hearts and unsound lumber.

Cull shall comprise all widths and sizes below the description of common.

NOTE—Gum spots are considered a serious defect and when their damage exceeds one-sixth of the size of the piece shall reduce it to the grade of common. When their damage exceeds one-third of the size of the piece, it shall be reduced to cull.

BUTTERNUT AND CHESTNUT.

The inspection grades shall consist of firsts and seconds, common, and cull.

Firsts and seconds must be 6 inches wide and over. At 8 inches may have one inch of sap or one standard knot, and at 10 inches two inches of sap or two standard knots. An allowance for more defects of this character may be made in proportion to increased width.

Common shall be 5 inches and over wide. At 6 inches one inch of sap or one standard knot, and at 8 inches two inches of sap or two standard knots may be allowed. An allowance for more defects of this character may be made in proportion to increased width.

Cull shall comprise all widths and sizes below the description of common.

GUM.

The inspection grades shall consist of firsts and seconds, common, and cull.

Firsts and seconds must be 6 inches wide and over. At 8 inches one standard knot, and at 10 inches two standard knots or one inch of bright sap may be allowed. An allowance for more defects of this character may be made in proportion to increased width.

Common shall include all lumber available for use full three-fourths of its size without waste, free from hearts and unsound lumber. Clear sap may be included in this grade.

Cull shall comprise all widths and sizes below the description of common.

HARD AND SOFT MAPLE.

The inspection grades shall consist of firsts and seconds, common, and cull.

Firsts and seconds must be 5 inches wide and over (except flooring). At 8 inches one, and at 10 inches two standard knots may be allowed. An allowance for more defects of this character may be made in proportion to increased width.

Common shall be sound, 5 inches and over in width, and may have defects not injuring it for ordinary use without waste. At 6 inches one and at 8 inches two standard knots may be allowed. An allowance for more defects of this character may be made in proportion to increased width.

Cull shall comprise all widths and sizes below the description of common.

BASSWOOD.

The inspection grades shall consist of firsts and seconds, common, and cull.

Firsts and seconds must be 6 inches wide and over. At 8 inches one and at 10 inches two standard knots may be allowed. An allowance for more defects of this character may be made in proportion to increased width. Bright sap is no defect.

Common shall include 5 inches and over wide. At 6 inches one, and at 8 inches two standard knots may be allowed. An allowance for more defects of this character may be made in proportion to increased width. Slightly discolored sap is allowed.

Cull shall comprise all widths and sizes below the description of common.

BIRCH.

The inspection grades shall consist of firsts and seconds, common, and cull.

Firsts and seconds must be 6 inches wide and over.

At 8 inches one and at 10 inches two standard knots may be allowed. An allowance for more defects of this character may be made in proportion to increased width. Bright sap is no defect.

Common shall be sound, 5 inches and over in width, and may have defects not injuring it for ordinary use without waste. At six inches one and at 8 inches two standard knots may be allowed. An allowance for more defects of this character may be made in proportion to increased width.

Cull shall comprise all widths and sizes below the description of common.

BEECH AND SYCAMORE.

The inspection grades shall consist of firsts and seconds, common, and cull.

Firsts and seconds must be 6 inches wide and over. At 8 inches one and at 10 inches two standard knots may be allowed. An allowance for more defects of this character may be made in proportion to increased width.

Common shall be sound, 5 inches and over wide, and may have defects not injuring it for ordinary use without waste. At 6 inches one and at 8 inches two standard knots may be allowed. An allowance for more defects of this character may be made in proportion to increased width.

Cull shall comprise all widths and sizes below the description of common.

ELM.

The inspection grades shall consist of firsts and seconds, common, and cull.

Firsts and seconds must be 6 inches wide and over. At 8 inches one and at 10 inches two standard knots may be allowed. An allowance for more defects of this character may be made in proportion to increased width. Bright sap is no defect.

Common shall include 5 inches and over wide. At 6 inches one and at 8 inches two standard knots may be allowed. An allowance for more defects of this character may be made in proportion to increased width.

ASH.

GRADES.—FIRSTS, SECONDS AND CULLS.

Firsts are to be 8 inches and over in width.

8 to 12 inches wide shall be clear.

13 to 15 inches wide will admit one standard knot, showing only on one side.

16 to 20 inches wide will admit two standard knots, showing only on one side.

Live white sap allowed.

Seconds are to be 6 inches and over in width.

6 and 7 inches wide shall be clear.

8 to 12 inches wide will admit one standard knot.

13 to 15 inches wide will admit two standard knots.

16 to 20 inches wide will admit three standard knots.

STRIPS.

4 to 5 inches wide shall be clear, or clear one side.

Heart, or doted, boards and plank will not be admitted in firsts and seconds.

Culls include all lumber not equal to the grade of *Seconds*, one-half of each piece being merchantable. Other than as above stated shall be classed as *mill culls*.

ASH JOISTS.

4 in. x 4 in. to 10 in. x 10 in. square.

Firsts are to be 10 feet and upward in length, clear, sound and free from all defects, and of full size when seasoned.

Seconds are to be sound and free from hearts, shakes, and checks.

10 and 12 feet lengths admit two standard knots.

14 and 16 feet lengths admit three standard knots.

Bright sap admitted. These defects are based on

6 in. x 6 in. joists, and are to bear the same ratio in other sizes.

Culls include all joists not equal to the grade of *seconds*, one-half of each piece being merchantable.

Other than above stated shall be classed as *mill culls*.

NOTE.—Ash flooring should be 3, 4, 5, and 6 inches wide, with one face and two edges clear, 1 and 1¼ inches thick, 12, 14 and 16 feet long. Common and cull strips have no value in market.

Ash newels and balusters same as black walnut.

Like all hardwoods, ash must be well manufactured to meet with ready sale at highest market prices. Wane and taper are serious defects.

SECOND GROWTH ASH.

Sawed through and through, and rough edged, shall be measured inside the wane, and in the center of the piece.

OAK.—(Plain.)

GRADES.—FIRSTS, SECONDS AND CULLS.

Firsts are to be 8 inches and over in width.

8 to 12 inches wide shall be clear.

13 to 15 inches wide will admit one standard knot, showing only on one side.

16 to 20 inches wide will admit two standard knots, showing only on one side.

Live sap admitted on one side, not to exceed one-tenth of the surface if without other defects. *Worm holes* not admitted.

Seconds are to be 8 inches and over in width.

8 to 12 inches wide will admit one standard knot.

13 to 15 inches wide will admit two standard knots.

16 to 20 inches wide will admit three standard knots.

Live sap admitted on one side, not to exceed one-fifth of the surface, if without other defects. *Worm holes* are serious defects, and should cull any piece, where enough appear to equal one or more standard knots, according to the width of the piece.

Culls include all lumber not equal to the grade of *seconds*, one-half of each piece being merchantable. Other than as above stated shall be classed as *mill culls*.

Oak *sawed through and through*, not edged, shall be measured inside the wane, and tapering pieces are to be measured in the center.

It is the nature of oak to crack in drying, not only in the ends but on the face, and it should be the study of the sharp-sighted mill-man to reduce that feature to a minimum. First of all paint the ends of the logs, put into every gallon of paint one-half pint of salt, and when the lumber is sawed and ready to pile place the sticks close together and directly over each other, and, above all things, thoroughly protect the lumber from the sun and rain. Heavy dews and occasional rain-falls, followed by the rays of a burning sun, will spoil the best of oak in a very short time; it therefore pays to put a substantial covering over each pile.

Shippers should bear in mind that common or cull oak is particularly unsaleable in any market. Only good, sound stock is wanted.

EXPORT OAK.

Oak for export should be 1 inch, 1½, 2, 2½, 3, 4, 5 and 6 inches thick, 10 inches and over wide, 12, 14, and 16 feet long. The more 14 and 16 feet the better, but never less than one-third of each length. It must be square edged and butted, parallel widths, plump and even thickness and well manufactured, free from heart, checks, splits, large or loose knots, or worm holes. This inspection is very comprehensive, and will admit of no deviation. For instance, it says 10 inches and over wide—9½ inches will not do. It says free from heart. Don't think because the plank is 6 inches thick, and the heart comes right in the center, and won't show on either side that it will go, for it won't. Follow strictly the rule, and you can find a good market for all the export oak you want to cut.

QUARTERED OAK.

GRADES.—FIRSTS AND SECONDS.

Firsts are to be 6 inches and over in width.

6 to 9 inches wide shall be clear.

10 inches and over in width will admit one standard knot, showing only on one side, or equal defect.

10 inches and over in width will admit two standard knots, or equal defects.

STRIPS.

4 to 5 inches wide shall be clear, or clear one side.

Worm holes, in excess of the defects allowed for knots, and stained or discolored wood, not admitted.

WARPAGE AND SHRINKAGE OF LUMBER.

What causes lumber to warp in the many various ways, yet remains to be solved. All kinds of lumber in small dimensions will warp in seasoning if not placed directly on sticks. This is the remedy, in short. The unequal shrinkage of the grain has much to do with crooked lumber. Lumber from crooked or leaning trees will warp badly. Second growth timber is very bad about warpage in seasoning. If one side of a board is dried faster than the other, it will contract, thus cupping or concaving that side. Lumber freshly sawed will warp always from the heart. There seems to be an unequal strain on the grain before it is cut. Often a straight tree will turn out badly sprung timber. This can be noticed when the grain shows irregularities, which show unequal stress. This is not shown so plainly when first sawed, but if remaining exposed for but a short while will warp and spring badly. Natural air drying is the best for oak, especially for a while, until partly seasoned. Oak and other valuable timber should not be stacked up in open air without a shed over it, which should be elevated and protect the ends of lumber from dampness. Narrow and open piles are what is wanted for a free circulation of air. The hot rays of the sun bring about an action that terminates in checked ends. Artificial drying of oak by the many kiln processes is not successful. Where the heat is normal and of a low temperature, narrow stock may be successfully dried from checking. The ends of such lumber should be painted with a thick coating of waterproof white or redlead paint. Broad boards should be cleated on ends. Sticks should be not over three feet apart, with weights on top course. Great care should be taken not to have pile too wide and with one inch space between boards.

WHEN TO CUT VALUABLE TIMBER. WHAT CAUSES OAK AND OTHER WOODS TO BE BRASHY.

Porous timber, such as oak, ash and hickory, should not be cut in the spring when the sap is up. The pores of the wood are then open, the wood being in a growing state, and when dry remain so, which makes it more brittle and less durable.

This is accounted for by the abstraction of all the unctuous matter, which accounts for worms and other insects. During the fall and winter months the grain can be noticed as being less porous and containing more of the vegetable oil essential to its toughness and durability. This timber will dry much sooner when cut in the winter months.

DRY ROT IN TIMBER.

Prof. Bidlake, of Rhode Island, makes the following report on dry rot:

No wood which is liable to damp, or has at any time absorbed moisture and is in contact with stagnant air, so that the moisture cannot evaporate, can be considered safe from the attacks of dry rot.

Any impervious substance applied to wood which is not thoroughly dry tends to engender decay; floor covered with kamptulicon and laid over brick arching before the latter was dry; cement dado to wood partition, the water expelled from dado in setting and absorbed by the wood had no means of evaporation.

Wood work coated with a paint or tar before thoroughly dry and well seasoned is liable to decay, as the moisture is imprisoned.

Skirtings and wall paneling very subject to dry rot, and especially window backs, for the space between the woodwork and the wall is occupied by stagnant air; the former absorbs moisture from the wall (especially if it has been fixed before the wall was dry after building), and the paint or varnish prevents the moisture from evaporating into the room. Skirting, etc., thus form excellent channels for the spread of the fungus. Plaster seems to be sufficiently porous to allow the evaporation of water through it; hence, probably the space between ceiling and floor is not so frequently attacked, if also the floor boards do not fit very accurately and no oil cloth covers the floor.

Plowed and tongued floors are disadvantageous in certain circumstances, as when placed over a space occupied by damp air, as they allow no air to pass between the boards and so dry them. Beams may appear sound externally and be rotten within, for the outside being in contact with the air, becomes drier than the interior. It is well, therefore, to saw and reverse all large scantling. The ends of all timber, and especially of large beams, should be free, (for it is through the ends that moisture chiefly evaporates). They should on no account be imbedded in mortar.

Inferior and ill-seasoned timber is evidently to be avoided. Whatever insures dampness and lack of evaporation is conducive to dry rot, that is to say, dampness arising from the soil; dampness arising from walls, especially if the damp proof course has been omitted; dampness arising from the use of salt sand; dampness arising from drying of mortar and cement. Stagnation of air resulting from air grids getting blocked with dirt or being purposely blocked through ignorance. Stagnation may exist under a floor, although there are grids in the opposite walls, for it is difficult to induce the air to move in a horizontal direction without some special means of suction. Corners of stagnant air are to be guarded against.

Darkness assists the development of fungus; whatever increases the temperature of the wood and stagnant air (within limit) also assists.

SEASONING.

After careful experiments made on behalf of the Chicago, Burlington & Quincy Railroad, at Aurora, Ill., regarding the natural seasoning of various woods, it was concluded that oak began to season naturally in March or April; that pine lost moisture within a fortnight after its first exposure; that ash and poplar began the loss in April, and elm immediately on being exposed in January. With the exception of elm the seasoning of most woods ends with the summer months. All woods take up slight moisture during wet weather in fall and winter; pine of small dimension, like inch flooring, will absorb moisture during the wet months; one season of average weather is generally sufficient to season wood for purposes of construction.

WEIGHT OF WOODS.

The following list, giving the weight of hardwood per foot, board measure, has been prepared with great care, and in the main is correct. Some allowance must be made in the weight of fresh cut, as the same wood differs some in weight when green, in different localities:

Name of Wood.	Green lbs. to 1 ft.	Dry lbs. to 1 ft.
Ash	4½	3½
Apple	5	4
Beech	5	4½
Birch	4¼	3½
Basswood	3½	2¼
Chestnut	3½	3
Cherry	4	3¼
Cottonwood	7½	3
Cypress	4	2½
Cedar	4	3
Elm	4	3
Hickory	5	4½
Holly	5¼	4½
Lignum Vitæ	9	8½
Maple	5	4½
Mahogany	5¼	4¾
Oak	5½	4½
Poplar	3¼	2¾
Rosewood	8	6¼
Sycamore	5	4
Sweet Gum	3¾	2¾
Walnut	4½	3½
White Pine	4	2¾
Yellow Pine	4½	3½

HOW TO BE A SUCCESSFUL SAWYER.

It is not necessary for a sawyer to be a thorough machinist or millwright, but must acquire sufficient knowledge of machinery to keep a mill in good repair. It is necessary to watch the vital parts that affect the saw, engine and machinery, watching closely the small details which avert accidents. Saw and carriage, as well as the mandrel, must be kept in line. Keep saw round by jointing the teeth with a piece of grindstone, fire-brick or broken emery-wheel. Do not saw in a notch, but move sideways gently, or the corners will be ground off too much. Do not joint a saw with a bar of iron or file. The latter may be used if saw revolves very slowly. Keep the teeth of uniform length and pitch, so that all will cut and saw remain in balance. No two mills will run alike, neither will two new saws run alike on same mandrel. Then it is especially necessary to learn the so-called peculiarities of a saw.

First put the saw in good order by filing as directed in this book. If saw does not screw up flat on log side, either paper or hammer it; when straight, line it with the carriage and level the saw mandrel. Take out all end play, and see that bearings are a neat fit. If saw crowds from the log, give it a little more lead. If it heats in center it is because saw is too open for speed, or is not properly lined. If it heats on the rim the saw requires more tension. If it runs into the log it will then heat because of too much lead, either in saw, mandrel or filing. The lead in mandrel can be changed but little; neither can a saw be run with too much pressure on guides. The filing may be changed to lead the saw, the saw inclining always to the longest side of the tooth. If saw heats on rim without running into the log, the bearing next to saw should be tightened sufficiently to heat a little. Such a saw needs tensioning as treated in hammering, it being too stiff. Care should be taken not to feed too fast on the first side of a log, and not to take too heavy a slab when log is squared up. A saw may run in too much, especially after passing the heart. If engine has ample power and will hold up, saw will do better by giving it more feed. Invariably this will work. Knotty, tough logs should be sawed from the butt end; otherwise the log will pinch the saw badly. When a saw begins to heat in center it will lay over and assume a deadening, rumbling noise against the guide pins. In such cases do not crowd saw, or it will burn in blue spots; better move the guide a little.

No saw should be run too long without filing. The best saw in the world can soon be ruined by running too long before filing. In filing from one side of saw, be sure that teeth are square in front. This is determined by a slight "queaking" noise to file; not a "chatter" by any means, neither a free cut. If spring set is used, a little swaging must be done to keep the extreme point the widest with a sharp corner to tooth. Double spread teeth should not have needle or brier corners, neither a round, dull corner. A sharp saw should not be crowded for the first few lines, as its keen edge will be affected and crumble in a hard or knotty log. If saw is not true, do not try to close guides too much; better let saw run free than to have it whipping in the guides and heating. Use plenty of set, which must be uniform. If saw is true, runs true and has no lumps in it, a much less set may be used. When a saw heats all over it is because saw is dull or has not set enough. Because an 8″ gauge saw has one-quarter inch full set does not say that it will clear a full place in saw which heats and gives trouble. Too much set will not do, especially with too many teeth; the dust being cut fine, throats of teeth will not chamber it, thus heating the rim. A saw that heats at rim and center has no lead in mandrel and is held up too much with guide. Such a saw will run in considerably at top of cut, yet heating in center. This must be observed closely. Many men do not take the time to even think what is the matter with a saw, but keep moving guides, which only changes saw to no better running.

Keep the following in view for attaining success:

First.—See that saw is all right and hangs right on collar; if not, make it as near so as possible.

Second.—File the saw in accordance with the way it hangs on mandrel. No two saws screw up alike on mandrel, and should they apparently do so, will not run precisely alike. If saw leans a trifle from the log, and time and circumstances will not admit truing it, file it to lead a little into the log; if saw leans or dishes to the log, then move mandrel until saw will run right; but not too much, or center will heat.

Third.—In starting up a mill you are not familiar with, do not rush on the start. Feed saw gently and find its inclination, noting about the condition of its tension, and if wavy on rim, that is, snakes, move saw out a little with guides. If it leans too much from log, the mandrel must be moved (if right) out a little and saw filed a trifle into the log. If possible, make bearing next to saw run warm.

Fourth.—Notice carefully if saw inclines out of log and whether it is heating at center or not, which it will do if saw does not snake. A saw inclining out of log will run out more as feed is increased and less as decreased, but will not run out for a few feet and then turn in again. In such cases saw is loose on rim and not too open. All saws too open for speed will heat in center, first being certain that mandrel is in line.

Fifth.—See that carriage track is straight and practically level, both rails must exactly correspond, otherwise it will run in a wind, which gives much trouble in deep cuts by influencing saws. Carriage must also have but little end play to bearings. This allows a springy cant to heat saw in center by pulling carriage closer to saw. See that driving belt runs smooth. A thumping joint will affect a saw by imparting a vibration to mandrel, especially if too light and springy.

Sixth.—Any saw will run better if a light spray of water can be applied on the log side by a small jet under control of sawyer. It acts as a lubricant, which, as oil in a bearing, keeps it cool. The saw certainly is exposed to considerable unavoidable friction. It is not best to have a sluice of water applied to wet mill and dampen dust so as to clog conveyor, but a gentle spray that cannot be noticed will add a twenty per cent. better running saw in hard or dry logs.

THE SAWYERS' RULE.

HOW TO MAKE QUICK, ACCURATE CALCULATIONS FOR WHAT IS WANTED FROM THE LOG.

There are many sawyers, setters that are not quick in their calculations, losing time and spoiling lumber. No man can be quick calculating one piece at a time. He must have it instantly in his head, that no time be lost.

CALCULATING ON INCH STUFF.

Every five inches makes four boards on a saw cutting one-quarter inch. Now, if one inch is to be left on blocks, five, ten, fifteen and twenty inches, and so on, will come out right. If cant is between these numbers, say about eighteen inches, set at eighteen and three-fourths, and so on. Now, if one or more two-inch pieces are wanted, leave off one-fourth inch for every two-inch piece wanted. If four two-inch pieces are wanted, nineteen inches will come out right, being one inch less than twenty inches. If two inches is left on headblocks calculate one-fourth less than a multiple of five inches, in this way twelve inches, eighteen and one-fourth and twenty-four and one-half will come out right.

SAWING TWO-INCH STUFF.

For as many pieces as are wanted add one-fourth of an inch for saw kerf as follows: If eight pieces are wanted it makes sixteen inches, add seven-quarters, makes seventeen and three-fourths inches. Correct. Always calculate one-fourth of an inch less, as the last line of the saw makes two pieces. If one or more inch boards are wanted, add one-fourth of an inch to calculation already made.

SAWING FIVE-EIGHTHS LUMBER.

Every three and one-half inches makes four five-eighths boards. For seven, ten and one-half, fourteen, seventeen and one-half, and so on, add two inches for last piece on carriage. Three-quarter inch stuff sets at even inches. Inch and a quarter lumber sets at one and one-half, three inches making two boards.

FOR THIN SAWS.

Many mills use a ten gauge saw,cutting three-sixteenths saw kerf. In such cases inch stuff may be set at one and one-eighth, making inch stuff seven-eighths inch full. If blocks set to sixteenths of inch, one-sixteenth can be saved, which is one board gained in sixteen cuts. Setting one-eighth inch less for inch boards the calculation is the same as for two-inch stuff as stated.

BAND SAW KERF.

One-eighth is allowed for saw kerf. Inch boards calculate as follows: If cant is about eighteen inches (no well-up sawyer can take time to be measuring with his rule), twice eight being sixteen inches, now we have seven-quarters to add, being seventeen and three-fourths or add one board, making eighteen and seven-eighths. It is necessary to first find out how many boards make an even number, or as near that as possible; then double, or multiply this number according to size of log.

SHORT METHOD OF CALCULATING LUMBER.

The rule for calculating lumber is to multiply the thickness by the width in inches, then by the length in feet, and divide by twelve. This is the only rule; but it can be greatly modified as follows: 100 pieces 1 x 10 x 12 feet. Now we multiply 100 x 10, which without figuring is 1,000. Now to multiply by 12 makes 12,000. This divided by 12 makes even 1,000 feet.

The short method leaves the 12 out and says 10 times 100 is 1,000 feet of lumber—no figuring at all. Any part of or factor of 12 may be left out and divided by the remaining factors, as follows: 876 pieces 3 x 4 x 20 feet. Leave the figures 3 and 4 out, and twenty times 876 is 17,520. Again: 56 pieces 4 x 8 x 18 feet. We leave the 4 out, then say 3 into 18 goes 6 times, 3 being the other factor of 12, as 3 and 4. Now you have only 56, 8 and 3 to be multiplied together, which makes the correct answer. If the whole were to be multiplied together, then divided by 12, it would take considerable time, which is more likely to result in errors.

Where it is possible, leave out the following figures: 2, 3, 4, 6 and 12, but not any more than will make 12 when multiplied together, as 2 x 6 is 12, or, 3 x 4 is 12. If desired, any one of the above factors may be left out separately, as follows: 125 pieces 6 x 16 x 22. Leave out the 6 and divide the remainder by 2, the other factor. This not only saves the time of multiplying the 6 together but saves the division of 12.

LUMBER MEASURED BY CANCELLATION.—A LIGHTNING METHOD.

Anyone that will familiarize himself with calculating lumber by cancellation after my method has no use for the many page calculators figured out in books. Fractions are as readily calculated as whole numbers;

and examples that would require one thousand figures or more to work can be almost instantly cancelled, with all fractional parts included, making the correct answer. Not one man in one hundred can work the following example correctly, which I show readily cancels out. First some explanation of this is necessary. Multiply the whole numbers by the fraction below the line (the denominator), and add the fraction above the line (the numerator) to the result, as in the example below: $8\frac{2}{7}$ multiplied together is $\frac{58}{7}$, 7 times 8 being 56, adding the 2, making 58. Fractions in the calculation of the size and number of feet have their denominator placed on the left side of a vertical line. This example is of a most difficult type, and is beyond the range in lumber calculations; but it expresses the simpleness of the method. What will $7\frac{1}{5}$ pieces of $8\frac{2}{7}$ x $8\frac{3}{4}$ x $21\frac{1}{3}$ feet long cost at $12\frac{4}{5}$ dollars per 1,000 feet?

The sizes, number of pieces and lengths of the lumber have their denominators placed on the left, as stated. The price at which it is sold being placed on the right, add 12, or the factors of 12, on the left side. Answer, $11.60. By leaving the price of the lumber out ($\frac{5}{64}$), we have 908 feet of lumber.

Explanation: 12 crosses 36 3 times; 3 checks 3 on the left; 5 checks 35 by 7 times; 7 cancels 7 on left; 64 checks 64 on the left. We have only 4 on the left hand and 58 and 5 on right; 5 times 58 is 290, and 4 times 290 is $11.60. In the case of the calculation of feet, only what figures remain on the left hand side after cancellation are divided into the numbers that remain on the right after they are all multiplied together. How many feet in 14 pieces $5\frac{1}{4}$ x $8\frac{1}{2}$ x 16 feet long? Answer, 833 feet.

In this example we use 3 and 4 as factors of 12. In cancellation all numbers that will divide from both sides without a fraction can be cancelled. The ordinary method of calculating lumber is to multiply the width and thickness together, then the length by the number of pieces and divide this by 12, the number of square inches in a foot of lumber. The last example given is a fair specimen. Tapered lumber has the two ends added together and divided by two, then proceed. Anyone that once adopts this mode of calculating lumber will never drop it. Being simple, it insures correctness. Where the piece is to be multiplied, put the denominator on right and the whole number on left, and multiply it by the result. Dressed lumber is calculated as rough, that is, the size it was before being dressed.

HOW TO SUCCESSFULLY RUN A PLANER.

To manage such machinery and get out first-class work requires great care and close judgment. A planer should be set on a solid foundation with all fast moving parts well balanced. In new machines, such are well balanced. The cylinder and cutter-heads being the most sensitive, they must run a neat fit in bearings, with sufficient lining, so that caps will remain firm and not jar or work loose. Every machine should have a pair of proportionate balance scales for balancing knives. If these cannot be had, an ordinary pair of balances will answer, care being taken to keep knives of same width at each end; otherwise the knives might weigh just the same amount and each alternate end of two knives throw the cylinder out of balance. The fraction of an ounce will greatly affect a high-speeded machine. The bolts should all be the same size. Often a miscellaneous lot of studs can be found on a cylinder, which would throw machine out. An unbalanced cylinder has many peculiarities about it that affect the whole machine. Hot bearing and rough lumber are the results. By placing cylinder on two *level* straightedges it can be readily detected whether in balance or not, the heavy side finding the center of gravity very quickly. This should be done with knives off. By grinding the bolts on heavy side, a perfect balance can be had, always screwing it down to where it is to run; if not, it will deceive. Knives out of balance wear the heavy side of journal flat, or slightly so. In such cases it is very difficult to get good work out of machine. I will add that before placing cylinder on straightedges, bearing should be calipered so the truest part will rest directly on straightedge. Clean cylinder and pullies well of dust and gum before testing.

Belts should be neatly spliced. A bulky fastening makes waves at regular intervals, to say nothing of such fastenings continually pulling loose and heating bearings. The chip-breaker, pressure-bars and rollers are vital parts. They must be set just right or the end of board will be nicked. The pressure-bars just behind the knives should be set as closely as possible, or lumber will be wavy. Modern six and eight-roll machines have very powerful feed and will feed under heavy pressure; but the lighter four-roll machines require continual attention in surfacing.

Dry and green lumber cannot be dressed well together. The green stuff not being as firm, requires more pressure and less pressure from pressure-bar. The bar "shoe," or roller, in front of cylinder must be set very closely so as to hold work down firm on bed plate for smooth lumber. The pivoted bar is best, as it readily accommodates itself to irregular thicknesses. The pressure-bars fore and aft the cylinder must be kept closely but so as to not interfere with feed. The rollers and bed plate are very essential parts. The latter should be nearly on line with top of bottom roller or a trifle lower. For green lumber, bottom rollers must be a little higher, otherwise work will not feed. The boards should go end to end through machine.

The fence, or gauge, is another important feature, and unless right, bad results will follow in matching. It is best to have just as little lead as possible and use a pressure-lever to hold crooked stuff up. The result of too much lead is that the end of board jumps, or rather, inclines, toward groove side as the end of gauge is passed. This makes bad work. The cause of this is that the stock is going through at a slight angle and not square with rolls. The chip-breaker should not be too tight. All this is governed by the amount of pressure from pressure-bar and power of feed rolls. Chip-breaker should be as close as possible to cutter-head, that it may not "eat," or tear, the work. Knives set too far out on cylinder will eat when across the grain.

For fine, nice work one-eighth should be the projection from lip of head; three-sixteenths is about right for ordinary work. Knives must be ground true and not beveled off with a file. The proper angle cannot be given, owing to class of work; but would say fifteen degrees is about right. A good knife will stand more than this and do nice work; but the majority have hard and soft places, which, if too much angle, will crumble or turn the edge. A slim bevel must be set close to the lip (or chip-breaker, as termed) of the cylinder, or it will eat in crossgrain work, as in curly stock.

Side cutters often give much trouble, principally from bits being out of balance or spindle not a neat fit to head, throwing it out of balance. A journal that heats and wears very fast under precaution is invariably because the head is out of balance and should be taken out and balanced. No perceptible (or but little) end play should be given. If too close, the least heat will make spindles longer by expansion and will heat much worse.

The question often arises, What causes a wave or niche in the front end of board? There are several direct causes. First, rollers and bed-plate are not in line; front pressure-bar not close enough; bed-plate too low or too high and not level; that is, parallel with roller; too low, so that stock will not rest on it without pressure from pressure-bar. The result often (with bar as tight as possible) is a niche in end of work. This is caused by work not fitting firmly to bed-plate, which causes lumber to give down when the second pressure-bar takes it. This defect ranges from two to four inches from end of board. This being remedied, the rear end of board may nick. This is caused by bed-plate not being high enough on front side, and when pressure-roller leaves board, causes it to raise slightly, thus making a bad end. As stated, the lower rollers must be level and in line parallel to each other, with bed-plate a trifle lower than rollers. If the board is nicked at each or one end when pressure-bars were down it is because it is not quite high enough. If too high, the same result is had.

On lower cylinders, the rear bed-plate should be one sixty-fourth inch lower, or in proportion to what cut is taken. In setting the gauge (fence or lead), a line is drawn clear through machine square with rollers. Then set gauge so that front end will be one-half inch farther from line than end near cylinder. Rollers must be kept square and of same height. An uneven pressure will tend work to run crooked. Rollers must be kept free from gum. Gearing should be well cared for, and where exposed should be oiled on the teeth, and where fended may be oiled. The modern machine with exhaust fan keeps shavings out, and generally gearing is open. Loose motion should be avoided, and rollers kept clear. Cut gearing is much better and runs more steady. No rough gear can be perfect which causes unsteady feed with a jerking motion. This causes rough work. Only a close application of thought and time will develop fine results. The aim must be toward the sensitive parts, and because a board will go through a machine do not be content that it is in good order. Few men have mastered the planer.

SPEED AND FEED OF PLANERS.

This is conditional. A true journal, well-balanced cylinder, and heavy, well-set machine will do good work at a speed of four thousand five hundred revolutions, feeding seventy-five feet per minute. There are many machines that feed one hundred feet and do good work. On the other hand, a light machine with unbalanced knives will not stand over two thousand five hundred revolutions and a feed of thirty to forty feet per minute. The limit may be said to be left with the skill of operator, taking into consideration the wear and condition of machine. All machines should be watched. Loose-threaded bolts subjected to much jar or strain are liable to work loose.

ON MATCHING.

A planer may surface well and do good work until it comes to the matching of flooring and ceiling. Side cutters must have but visible end motion; otherwise the irregularity of the grain will take up the loose motion, making stuff that will not match in places. I have seen two boards come out of a machine perfect, and in less time than it takes to tell it two more were tried that did not match. The pressure-bars should press equally on the board, and not too heavy next to the gauge, as it will climb off. Too much lead, as stated, will cause trouble. The rear guides have but little to do more than guide the work. A well-lined, level machine does not depend on the aft guides for good work. Feed rollers must not be too tight on work. Dull and badly fitted knives give much trouble, in that soft boards are cut thinner than harder ones. Dull knives do not cut, but knock it off. Dull knives often heat bearings.

SETTING KNIVES.

Put a couple strips on bed-plate lower cylinder until they are firm; turn cylinder until knife will rest on strips, being certain that both ends are down. Then tighten this knife cautiously. Then with a pointer set to just touch this knife, and all the remainder set to just the same feeling or hearing. Some use a gauge set from the lip of cylinder, which is not always perfect.

BABBITTING CYLINDER BEARINGS.

Many experts recommend a form or separate mandrel to babbitt with. This is not necessary and is not attended with good results, as it does not conform to the wear of journals.

The theory is that heat from the metal elongates that side and is liable to spring journals. This might be adhered to if no precaution is taken, but a little precaution overcomes this. By heating the cap of box to nearly a red heat, laying it in place with mandrel in position for babbitting; by moving it frequently, the journal will be heated and allays all danger of springing. This must be adhered to or there is liability of springing journal permanently. After metal has cooled sufficiently, remove cylinder and scrape boxes out, scraping the "lip," and not the crown. By screwing caps down to place, a pair of calipers will show that from crown to crown is more than directly where cap and box come together, which shows the contraction of metal. About one-third of the bearing should be nicely scraped, then place journal in bearings having a thin coat of redlead applied. Now turn cylinder a few times and carefully remove it. Thus the high spot will plainly show and must be scraped down. All this is necessary for good work and cool journals from high-speeded machines. The same applies to the cutter-heads. If journals heat use plumbago, tallow and sulphur. Soda is good. All must be prepared in good lubricating oil. Never use black oil on a planer. Use lard or some other good thin oil. The gearing and feedworks are generally worn out before the machine is for the want of proper oiling.

BUILDING PLANING MILLS—HOW TO CONSTRUCT FOR ECONOMICAL PLANING.

It is not the actual expense of dressing that is the item of cost in many planing-mills. It is in the handling of lumber both to and from the machines. There is more money in planing than in sawing if mill and machinery is constructed right.

If a dry kiln is used it should be so set that the lumber from kiln cars will stop within three feet of machine, the feeder taking the stock direct from car. If there is any rejected stuff it is simply dumped off, where it is laid aside until an accumulation for a second grade. From the planer, lumber is placed on car or trucks and carried to shed, car or wharf. If only one machine is used, a rack just aft the machine may be employed, where the receiver can place the majority of stock right into racks. Every machine should have an exhaust fan, well constructed, that is, well made, and set-up pipes. Resaw or siding machine, should be set back of planer, and a little to one side, and speeded to feed the same as the planer; then the receiver can feed the resaw, which product goes out as stated. Conveniently and direct aft the planer, say twenty feet, should be a neat-sawing cut-off saw with a fine-toothed saw. All stock from planer that has a defect that would condemn it or place it in a lower grade can be trimmed to an even foot and go onto the market and meet the most rigid inspection.

The table of this saw should be at least three inches lower than planer, so that the next board or the third board would not jam saw in case time was lost, saw, when not in use, swinging back clear.

Rip saw should be between matcher and surfacer, if two machines are used, and should be set as far ahead as possible by using a long belt. This, as well as all the machinery, is driven from line shaft running across mill with planers almost directly under it, so that slacking the tightener, machine stops without difficulty. Resaw and swing-saw must have a short counter shaft, the latter driven by a miter friction. If a moulder is to be used, it should be directly off the rip saw table, as nearly all its work comes from irregular widths in edging boards. The distance between saw and moulder in this case would be about thirty feet. Lumber to be received from the yard can come in on as many tracks as desired, having a turn-table placing everything direct to machine.

To illustrate: Many mills have no car track, using teams and delivering stock not near enough but that it requires the second handling. Too little attention is paid to grading lumber, and the planer man has to lose a part of the machine's time in assorting a part of this. After going through machine it is rejected either from the want of edging, trimming or redressing. The culled lumber in front of planer soon accumulates and has to be removed, in many cases restacked. The culled stuff through planer is thrown down, walked over, thrown aside, and sold for what it will go at. I will add that a planing-mill with competition cannot survive without close inspection, which must come right from the saw-mill. Few mills have a standard matching gauge, which all associations have adopted. This is a good thing for the competent man, but very seriously against the man that does not consider it. Mr. A. gets a lot of flooring from Mr. B. He lacks a little, and calls on Mr. C. for that size. He gets it and finds that it will not match; returns it to Mr. C. Not that it is not good, well-worked stuff, but it's not up to the standard. Some do not adhere to a gauge of their own, and soon have a mixture that the cheap man gets lumped up for so much, which price may not exceed the value of the rough stock before dressing. The southwestern yellow pine standard admits of the following sizes without changing the tongue or groove: Three-fourths, thirteen-sixteenths, seven-eighths, one, and one and one-sixteenth inches. It is evident that stock that will not full-dress any of the heavier sizes can be run through the surfacer and brought to the next gauge ceiling, three-eighths, one-half, nine-sixteenths, and five-eighths inches, without changing tongue or groove.

LOG SCALE.

ROUND LOGS REDUCED TO INCH-BOARD MEASURE FROM VARIOUS RULES.

DOYLE RULE.—BOARD MEASURE.

L.	Diameters. Inches.								
Ft.	8	9	10	11	12	13	14	15	16
10	10	16	23	31	40	50	62	75	90
12	12	19	27	37	48	61	75	91	108
14	14	22	32	43	56	71	88	106	126
16	16	25	36	49	64	81	100	121	144
18	18	28	41	55	72	91	112	136	162
20	20	31	46	61	80	101	125	151	180
22	22	34	50	67	88	111	137	166	198
24	24	37	54	74	96	122	150	181	216

L.	Diameters. Inches.								
Ft.	17	18	19	20	21	22	23	24	25
10	106	122	141	160	181	202	226	250	276
12	127	147	169	192	217	243	271	300	331
14	148	171	197	224	253	283	313	350	386
16	169	196	225	256	289	324	359	400	441
18	190	220	253	288	325	364	406	450	496
20	211	245	280	320	361	404	452	500	551
22	232	269	309	352	397	445	496	550	606
24	253	294	338	384	433	486	541	600	661

L.	Diameters. Inches.								
Ft.	26	28	30	32	34	36	38	40	42
10	302	360	422	490	562	640	723	810	902
12	363	432	507	588	675	768	867	972	1083
14	423	504	591	686	787	896	1011	1134	1264
16	484	576	676	784	900	1024	1156	1296	1444
18	544	648	761	882	1012	1152	1300	1458	1625
20	605	720	845	980	1125	1280	1446	1620	1805
22	665	792	930	1078	1237	1408	1590	1782	1986
24	726	864	1014	1176	1350	1536	1734	1944	2166

L.	Diameters. Inches.								
Ft.	44	46	48	50	52	54	56	58	60
10	1000	1103	1210	1322	1440	1562	1690	1822	1960
12	1200	1323	1452	1587	1728	1875	2028	2187	2352
14	1400	1544	1694	1850	2016	2187	2366	2551	2744
16	1600	1764	1936	2116	2304	2500	2704	2916	3136
18	1800	1985	2178	2380	2592	2812	3042	3280	3528
20	2000	2206	2420	2645	2880	3125	3380	3645	3920
22	2200	2426	2662	2909	3168	3437	3718	4009	4312
24	2400	2646	2904	3174	3456	3750	4056	4374	4704

SCRIBNER RULE.—BOARD MEASURE.

L. Ft.	Diameters. Inches. 8	9	10	11	12	13	14	15	16
10	15	22	30	40	49	61	72	89	99
12	19	27	37	48	59	73	86	107	119
14	22	32	43	56	69	85	100	125	139
16	25	36	49	64	79	97	114	142	159
18	28	40	55	72	88	109	129	160	178
20	31	45	61	80	98	122	143	178	198
22	34	49	67	88	108	134	157	196	218
24	37	54	73	96	118	146	172	214	238

L. Ft.	Diameters. Inches. 17	18	19	20	21	22	23	24	25
10	116	133	150	175	190	209	235	252	287
12	139	160	180	210	228	251	283	303	344
14	162	187	210	245	266	292	330	353	401
16	185	213	240	280	304	334	377	404	459
18	208	240	270	315	342	376	424	454	516
20	232	267	300	350	380	418	470	505	573
22	255	293	330	385	418	460	518	555	631
24	278	320	360	420	456	501	566	606	688

L. Ft.	Diameters. Inches. 26	27	28	29	30	31	32	33	34
10	313	342	363	381	411	444	460	490	500
12	375	411	436	457	493	532	552	588	600
14	439	479	509	533	575	622	644	686	700
16	500	548	582	609	657	710	736	784	800
18	562	616	654	685	739	799	828	882	900
20	625	684	728	761	821	888	920	980	1000
22	688	753	800	838	904	976	1012	1078	1100
24	750	821	873	914	986	1065	1104	1176	1200

L. Ft.	Diameters. Inches. 35	36	37	38	40	42	44	46	48
10	547	577	644	668	752	840	925	991	1080
12	657	692	772	801	903	1007	1110	1190	1296
14	766	807	901	934	1053	1175	1295	1388	1512
16	876	923	1029	1068	1204	1343	1480	1587	1728
18	985	1038	1158	1201	1354	1511	1665	1785	1944
20	1095	1152	1287	1335	1505	1679	1850	1983	2160
22	1204	1268	1416	1470	1655	1847	2035	2181	2376
24	1314	1380	1544	1604	1806	2015	2220	2380	2592

Scribner's and Doyle's rules are considered the standard. Doyle's rule is used in Scribner's Lumber and Log Book. I have measured large logs and find that Doyle's rule will not hold out on logs over thirty-six inches in diameter. Scribner's rule is the nearest right. The latter is nearer right on small logs, while Doyle does not give enough.

This table is computed for thin circular-saws that effect a saving in saw kerf.

LOGS REDUCED TO INCH-BOARD MEASURE.

Length in Feet.	Diam. 12	Diam. 13	Diam. 14	Diam. 15	Diam. 16	Diam. 17	Diam. 18	Diam. 19	Diam. 20	Diam. 21	Diam. 22	Diam. 23	Diam. 24	Diam. 25	Diam. 26	Diam. 27	Diam. 28
10	49	61	72	89	99	116	133	150	175	190	209	235	252	287	313	342	363
11	54	67	79	98	109	127	147	165	192	209	230	259	278	315	344	377	400
12	59	73	86	107	119	139	160	180	210	228	251	283	303	344	375	411	436
13	64	79	93	116	129	150	173	195	227	247	272	306	328	373	408	445	473
14	69	85	100	125	139	162	187	210	245	266	292	330	353	401	439	479	509
15	74	91	107	134	149	173	200	225	262	285	313	353	379	430	469	514	545
16	79	97	114	142	159	185	213	240	280	304	334	377	404	459	500	548	582
17	84	103	122	151	168	196	227	255	297	323	355	400	429	487	531	582	618
18	88	109	129	160	178	208	240	270	315	342	376	424	454	516	562	616	654
19	93	116	136	169	188	219	253	285	332	361	397	447	480	545	594	650	692
20	98	122	143	178	198	232	267	300	350	380	418	470	505	573	625	684	728
21	103	128	150	187	208	243	280	315	368	399	439	495	530	602	656	719	764
22	108	134	157	196	218	255	293	330	385	418	460	518	555	631	688	753	800
23	113	140	164	205	228	266	307	345	403	437	480	542	571	659	719	787	837
24	118	146	172	214	238	278	320	360	420	456	501	566	606	688	750	821	873
25	123	152	179	223	248	289	333	375	438	475	522	589	631	717	781	856	910

LOGS REDUCED TO INCH-BOARD MEASURE.

Length in Feet.	Diam. 29	Diam. 30	Diam. 31	Diam. 32	Diam. 33	Diam. 34	Diam. 35	Diam. 36	Diam. 37	Diam. 38	Diam. 39	Diam. 40	Diam. 41	Diam. 42	Diam. 43	Diam. 44
10	381	411	444	460	490	500	547	577	644	669	700	752	795	840	872	925
11	419	451	448	506	539	550	602	634	708	734	770	828	874	924	959	1017
12	457	493	532	552	588	600	657	692	772	801	840	903	954	1007	1046	1110
13	495	534	576	598	637	650	712	750	836	868	910	978	1033	1091	1135	1203
14	533	575	622	644	686	700	766	807	901	934	980	1053	1113	1175	1222	1295
15	571	616	666	690	735	750	821	865	965	1001	1050	1129	1192	1259	1309	1388
16	609	657	710	736	784	800	876	923	1029	1068	1120	1204	1272	1343	1396	1480
17	647	698	755	782	833	850	931	980	1094	1134	1190	1279	1351	1427	1484	1573
18	685	739	799	828	882	900	985	1038	1158	1201	1260	1354	1431	1511	1571	1665
19	723	780	843	874	931	950	1040	1096	1222	1268	1330	1430	1510	1595	1658	1758
20	761	821	888	920	980	1000	1095	1152	1287	1335	1400	1505	1590	1679	1745	1850
21	800	863	932	966	1029	1050	1150	1210								
22	838	904	976	1012	1078	1100	1204	1268								
23	876	945	1021	1058	1127	1150	1259	1322								
24	914	986	1065	1104	1176	1200	1314	1380								
25	952	1027	1109	1150	1225	1250	1369	1438								

Band-saws save ten per cent. over the circular in the amount of lumber turned out. The difference in saw kerf being fifty per cent., by adding ten per cent. to log scale, the amount is had accurately.

TABLE

Showing the number of feet (board measure) contained in a piece of joist, scantling or timber, of the sizes given below.

SIZE IN INCHES.	LENGTH IN FEET OF JOISTS, SCANTLING, AND TIMBER.												
	12	14	16	18	20	22	24	26	28	30	42	44	45
2x 4	8	9	11	12	13	15	16	17	19	20	28	29	30
2x 6	12	14	16	18	20	22	24	26	28	30	42	44	45
2x 8	16	19	21	24	27	29	32	35	37	40	53	58	60
2x10	20	23	27	30	33	37	40	43	47	50	70	74	75
2x12	24	28	32	36	40	44	48	52	56	60	84	88	90
3x 4	12	14	16	18	20	22	24	26	28	30	42	44	45
3x 6	18	21	24	27	30	33	36	39	42	45	63	66	68
3x 8	24	28	32	36	40	44	48	52	56	60	84	88	90
3x10	30	35	40	45	50	55	60	65	70	75	105	110	113
3x12	36	42	48	54	60	66	72	78	84	90	126	132	135
4x 4	16	19	21	24	27	29	32	35	37	40	56	58	60
4x 6	24	28	32	36	40	44	48	52	56	60	84	88	90
4x 8	32	37	43	48	53	59	64	69	75	80	112	118	120
4x10	40	47	53	60	67	73	80	87	93	100	140	146	150
4x12	48	56	64	72	80	88	96	104	112	120	168	176	180
6x 6	36	42	48	54	60	66	72	78	84	90	126	132	135
6x 8	48	56	64	72	80	88	96	104	112	120	168	176	180
6x10	60	70	80	90	100	110	120	130	140	150	210	220	225
6x12	72	84	96	108	120	132	144	156	168	180	250	265	270
8x 8	64	75	85	96	107	117	128	139	149	160	224	234	240
8x10	80	93	107	120	133	147	160	173	187	200	280	294	300
8x12	96	112	128	144	160	176	192	208	224	240	336	352	360
10x10	100	117	133	150	167	183	200	217	233	250	3·0	366	375
10x12	120	140	160	180	200	220	240	260	280	300	420	440	450
12x12	144	168	192	216	240	264	288	312	336	360	504	528	540
12x14	168	196	224	252	280	308	336	364	392	420	588	616	630
14x14	196	229	261	294	327	359	392	425	457	490	686	716	735

BELTING—CARE OF.

HORSE-POWER AND HOW TO SELECT AN EXTRA QUALITY.

The saw and planing-mills are very hard on belting, owing to dust collecting and the want of the proper management and care. Any belt taxed to its capacity cannot do good work unless its surface is kept a little moist with a good belt dressing. Sawdust acts as small rollers between belt and pulley. A rubber belt soon wears the gum off. No pains should be spared to protect belts from dust. The time and power lost by tight and slipping belts needs no comparison. Castor-oil is about the best dressing that can be used on leather and rubber belts, but very little at a time, just sufficient to keep surface a little damp, but not a sticky mass. Do not use rosin in connection, as it will soon ruin your belt. A little powdered rosin on a dry belt may be used in emergencies, but sparingly. There are many belt "grips" on the market, and but few of them will preserve a belt. Tallow may be used sparingly on well-scraped or cleaned leather belts. The base of nearly all prepared compounds has more or less petroleum or hydrocarbon, which is very injurious to a belt. The merit of belt dressing is not in its adhesiveness, but in the preservation of the belt.

SELECTING BELTING.

We see many tables of testing belting, strained over two pullies with weight applied. This is not what the purchaser wants, nor has the time to do. The best leather belting is made from the central part of the hide and contains no flanky leather. Such belting when in a coil will show normally the same thickness, and not thick and thin parts. The best belting is strictly short-lap. If time will permit, a small piece of belt put in strong vinegar twenty-four hours will tell its quality. If good leather it will maintain nearly its thickness; if not, it will swell and be a spongy mass, which shows flanky leather. Rubber belting is not so easily detected from appearance. There is more cheap, worthless gum belting than leather. The best quality vulcanized has a smooth metallic surface and shows no small grainy or small indentations or irregularities on the surface. Cheap belting shows irregularities in the rubber when cut, which shows the composition used to imitate the rubber, viz.: old leather charred and ground up, mixed with sulphur, magnesia, black lead and Parra rubber, which is much cheaper than the Java. There are many more ingredients used that make up an article fifty to seventy-five per cent. cheaper than the genuine. Pure Java rubber shows no irregularities, has not a dry crumbly appearance. Cheap rubber belting will not stand much slipping or heat, as the rubber will crumble and roll off. The inside of some such belting contains a mixture of Cornwall or China clay, and soon forms a dry, dusty mass which separates the plies, and the belt is gone. I do not, on general principles, advocate the stitched rubber belting. The first and most serious objection is that more rubber must be applied, which, if of a good quality, will tend to fracture by showing small checks. A thin metallic surface with good rubber between the plies knocks all the patent stitched belting out. Genuine rubber belting is superior to leather in many ways. Seamless belting is the best if of the best quality.

FASTENING BELTS, LACING HOOKS AND RIVETING.

The manner of pulling belts together is badly botched in many mills. A bad splice or fastening will ruin the best belt made. High speed belts must have a smooth, even-running joint; otherwise the thump and jar passing over pulleys will soon tear it apart, to say nothing of hot bearings and wavy work from planing machines. The following engravings show three styles of lacing. There are many botch plans which it is not necessary to mention. The idea prevails among many that two or three lacings through one hole strengthen the joint. This is a mistake. Such lacing will soon tear out; if not, the bulky lace wears in two, and that is the end of the lace.

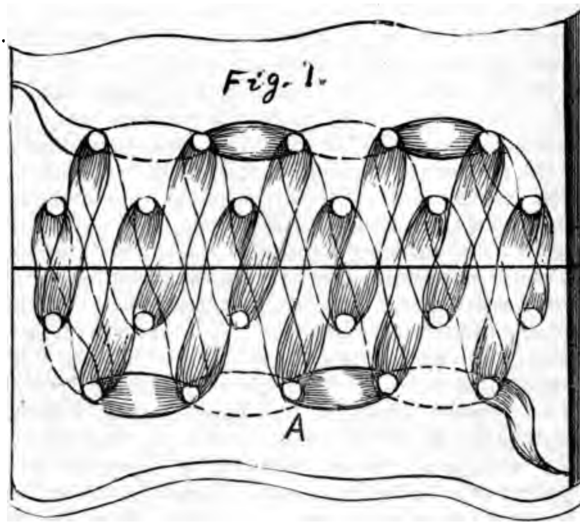


Fig. 1 shows a good lace for rubber and leather belts. The cut shows that lace is not crossed on either side. Dotted lines show lace on other side. *A* shows a cross-stitch run across belt after lacing is finished. This lace has no strain on it and is for preventing wear on the lace that holds the belt. This lace is of but one thickness, and if a good thin lace, well hammered after lacing, it will run very smooth and will remain good until belt requires taking up. Holes should be punched three-fourths from center to center and one-half from end of belt, second row one hole less and one-half from first row.

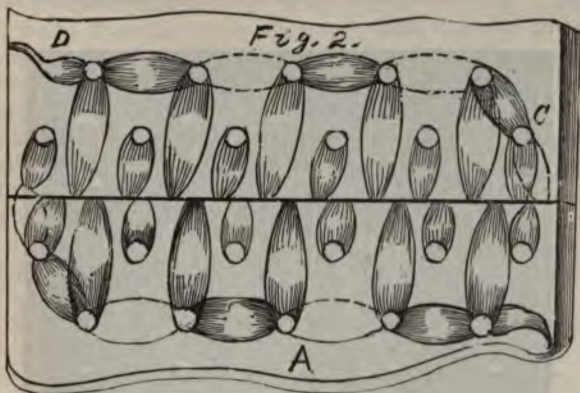
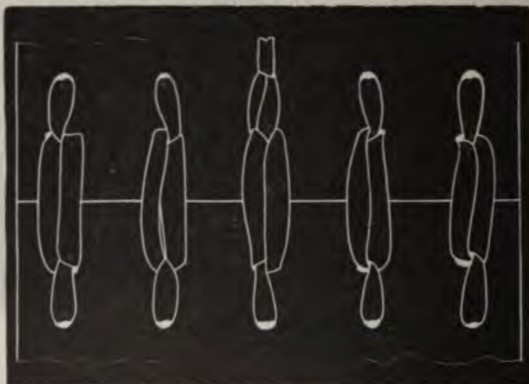


Fig. 2 shows the best lace for all purposes. It is termed the hinge lace, as it passes between end of belt, as shown in cut. This is the only lace that will successfully hold cotten-woven and stitched gandy belting. The lace passes alternately between end of belt, thus forming a clamp which prevents holes from ravelling and pulling out. This lace, as well as Fig. 1, is started in the centre of belt, starting at *A*, passing between ends of belt, coming through at the letter *g*, and so on. When this side is finished, lace the other half, then run the cross-stitch *A D*, as shown. This lace I have run for five years without replacing.

The main belting companies of Chicago say if belt-users would adopt my lace there would be but little complaint and no more trouble in using cotton-stitched belting. The holes are punched as in Fig. 1, using a small punch and one-half to five-eighths inch good lacing. With this lace a very small take-up can be made in short belts. Only one row of holes may be cut out; and by punching the same number back this lace will "pan" out, thus allowing as short as five-eighths inch taking out of a belt.



This cut shows the standard style of ordinary belt lacings, being laced two thicknesses, and needs no further explanation.

Belt hooks, as a general thing, are not the best for fastening belts. Covel's are the only hooks made that are reliable. When properly used, they not only make a good fastening but the equivalent to an endless belt. Leather belts may be cemented if not saturated with grease. The ends being neatly scarfed and a good belt cement at hand, apply quickly, then put splice under heavy pressure in a dry place. The ends of laps may be pegged or tacked down until dry, then use a sufficient number of small head rivets, which makes a stronger joint.

NOTES ON BELTING.

Don't overtax belts by overloading them or by running them tighter than necessary.

The whole arranger[illegible] hafting and pulleys should be under the direction of a mechanical engineer, or competent machinist. Destruction of machinery and belts, together with unsatisfactory results in the business, is a common experience which may, in most cases, be traced to a want of knowledge and care in the arrangement of the machinery, and in the width and style of the belts bought, and in the manner of their use, while the manufacturers of the "outfit" are often blamed for bad results which are caused by the faulty management of the mill owner himself.

Having properly arranged the machinery for the reception of the belts, the next thing to be determined is the length and width of the belts.

When it is not convenient to measure with the tape-line the length required, the following rule will be found of service: Add the diameter of the two pulleys together, divide the result by 2, and multiply the quotient by 3¼, then add this product to twice the distance between the centers of the shafts, and you have the length required.

The width of belt needed depends on three conditions: 1. The tension of the belt. 2. The size of the smaller pulley, and the proportion of the surface touched by the belt. 3. The speed of the belt.

The working adhesion of a belt to the pulley will be in proportion both to the number of square inches of belt contact with the surface of the pulley, and also to the arc of the circumference or the pulley touched by the belt. This adhesion forms the basis of all right calculation in ascertaining the width of belt necessary to transmit a given horse-power.

In the location of shafts that are to be connected with each other by belts, care should be taken to secure a proper distance one from the other. It is not easy to give a definite rule as to what this distance should be. Circumstances generally have much to do with the arrangement, and the engineer or machinist must use his judgment, making all things conform, as far as may be, to general principles. This distance should be such as to allow of a gentle sag to the belt when in motion.

A general rule may be stated thus : Where narrow belts are to be run over small pulleys—15 feet is a good average—the belt having a sag of 1½ to 2 inches. For larger belts, working on larger pulleys, a distance of 20 to 25 feet does well, with a sag of 2½ to 4 inches. For main belts working on very large pulleys, the distance should be 25 to 30 feet, the belts working well with a sag of 4 to 5 inches.

If too great a distance is attempted, the weight of the belt will produce a very heavy sag, drawing so hard on the shaft as to produce great friction in the bearings, while at the same time the belt will have an unsteady flapping motion, which will destroy both the belt and machinery.

If possible to avoid it, connected shafts should never be placed one directly over the other, as in such case the belt must be kept very tight to do the work. For this purpose belts should be carefully selected of well-stretched leather.

It is desirable that the angle of the belt with the floor should not exceed 45°. It is also desirable to locate the shafting and machinery so that belts should run off from each shaft in opposite directions, as this arrangement will relieve the bearings from the friction that would result when the belts all pull one way on the shaft.

The diameter of the pulley should be as large as can be admitted, provided they will not produce a speed of more than 3,750 feet of belt motion per minute. Some authorities limit this speed to 3,000 feet.

The pulley should be a little wider than the belt required for the work.

The motion of driving should run with and not against the laps of the belts.

Tightening or guide pulleys should be applied to the slack side of belts and near the smaller pulley.

Quick-motion belts should be made as straight and as uniform in section and density as possible, and endless if practicable, that is, with permanent joints.

Belts which run loose, will, of course, last much longer than those which must be drawn tightly to drive —tightness being evidence of overwork and disproportion.

Never add to the work of a belt so much as to overload it.

The transmitting power of a double belt is to that of single belt as 10 is to 7. In ordering pulleys, the kind of belt to be used should always be specified.

The strongest part of belt leather is near the flesh side, about one-third the way through from that side. It is, therefore, desirable to run the grain (hair) side on the pulley, in order that the strongest part of the belt may be subject to the least wear.

The flesh side is not liable to crack, as the grain side will do when the belt is old, hence it is better to crimp the grain than to stretch it.

Leather belts run with grain side to the pulley will drive 30 per cent. more than if run with flesh side. The belt, as well as the pulley, adheres best when smooth, and the grain side adheres best because it is smoothest.

A belt adheres much better and is less liable to slip when at a quick speed than at a low speed. Therefore it is better to gear a mill with small pulleys and run them at a high velocity than with large pulleys and to run them slower. A mill thus geared costs less and has a much neater appearance than with large, heavy pulleys.

Belts should be kept clean and free from accumulations of dust and grease, and particularly from contact with lubricating oils, some of which permanently injure leather.

Leather belts must be well protected against water, and even moisture.

India rubber is the proper substance for belts exposed to the weather, as it does not absorb moisture and stretch and decay.

Belts should be kept soft and pliable.

TIGHT BELTS.

Clamps with powerful screws are often used to put on belt with extreme tightness, and with most injurious strain upon the leather. They should be very judiciously used for horizontal belts, which should be allowed sufficient slackness to move with a loose, undulating vibration on the returning side, as a test that they have no more strain imposed than is necessary simply to transmit the power.

On this subject the following from a New England cotton mill engineer, of high reputation and large experience, is entitled to careful consideration :

" I believe that three-quarters of the trouble experienced in broken pullies, hot boxes, etc., can be traced to the fault of tight belts. The enormous and useless pressure thus put upon pulleys must in time break them, if they are made in any reasonable proportions, besides wearing out the whole outfit, and causing heating and consequent destruction of the bearings. If manufacturers realized how much this fault of tight belts cost them, in running their mills, probably they would 'wake up.' "

HORSE-POWER OF BELTING.

To ascertain transmitting power, multiply the diameter of driving pulley in inches by its number of revolutions per minute and this product by width of belt in inches; divide this product by 3,300 for single leather, four-ply rubber or four-ply cotton belting—or by 2,100 for double leather, six-ply rubber or six-ply cotton belting and the quotient will be the number of horse-power that can be safely transmitted.

TO FIND THE LENGTH OF A BELT WHEN CLOSELY ROLLED.

The sum of the diameter of the roll and the eye in inches multiplied by the number of turns made by the belt, and this product multiplied by the decimal, .1309, will equal length of the belt in feet.

TO FIND THE APPROXIMATE WEIGHT OF BELTS.

Multiply the length of the belt, in feet, by the width in inches and divide the product by 13 for single, and 8 for double belt.

NOTES ON SHAFTING.

Shafting must not be too light, neither with bearings too far apart. For small shafting, bearings should be from six to seven feet apart; and for shafting over two and one-fourth inches, eight to nine feet, according to amount of work and the pull of belts, which should be in opposite directions as much as practicable. Where belts pull one way friction is greater and will pull shaft out of line. A smaller shaft with bearings closer together will consume less power than a larger with a longer swing and will develop same power. A two-inch shaft with six feet between bearings will give as much power as a two and one-half inch with ten feet bearings, and consume much less power and remain in better line. Do not use burnt or crooked shafting because it is fifty per cent. cheaper than new. It will consume the difference in power and loss of time on every day's run. Buy only the new if a saving is to be effected.

TRANSMISSION TABLES.—SHAFTING.

Applicable to well supported line shafting from which power is taken at intervals by small or medium sized pulleys. *Not* applicable to prime movers (head shafts), jack shafts, or to line shafts, *carrying gears or extra large pulleys.* Such shafts should be from ¼ in. to one in. larger, according to circumstances, than the sizes given in the tables.

H. P.	DOUBLE SAFETY.—NUMBER OF REVOLUTIONS PER MINUTE.																
	25	30	35	40	45	50	55	60	70	80	100	125	150	175	200	250	300
1	1 3/8	1 5/16	1 1/4	1 1/4	1 3/16	1 3/16	1 1/8	1 1/16	1	15/16	7/8	13/16	3/4	3/4	11/16	5/8	1/2
2	1 13/16	1 11/16	1 9/16	1 1/2	1 7/16	1 7/16	1 3/8	1 5/16	1 1/4	1 3/16	1 1/8	1 1/16	1	15/16	7/8	13/16	3/4
3	2	1 15/16	1 7/8	1 3/4	1 11/16	1 5/8	1 9/16	1 1/2	1 7/16	1 3/8	1 5/16	1 3/16	1 3/16	1 1/8	1 1/16	1	1
4	2 1/4	2 1/8	2	1 15/16	1 7/8	1 13/16	1 3/4	1 5/8	1 9/16	1 1/2	1 7/16	1 5/16	1 1/4	1 3/16	1 3/16	1 1/8	1 1/16
5	2 7/16	2 1/4	2 3/16	2 1/8	2	1 15/16	1 7/8	1 13/16	1 3/4	1 5/8	1 1/2	1 3/8	1 5/16	1 1/4	1 1/4	1 3/16	1 1/8
6	2 9/16	2 7/16	2 1/4	2 3/16	2 1/8	2	1 15/16	1 7/8	1 13/16	1 3/4	1 5/8	1 1/2	1 3/8	1 5/16	1 1/4	1 3/16	1 3/16
7	2 11/16	2 9/16	2 7/16	2 1/4	2 3/16	2 1/8	2 1/16	2	1 15/16	1 7/8	1 13/16	1 9/16	1 1/2	1 3/8	1 5/16	1 1/4	1 3/16
8	2 7/8	2 5/8	2 9/16	2 7/16	2 1/4	2 1/4	2 3/16	2 1/8	2	1 15/16	1 13/16	1 5/8	1 5/8	1 1/2	1 7/16	1 5/16	1 1/4
9	2 15/16	2 3/4	2 5/8	2 1/2	2 3/8	2 5/16	2 1/4	2 3/16	2 1/16	2	1 7/8	1 3/4	1 5/8	1 1/2	1 1/2	1 3/8	1 5/16
10	3 1/16	2 7/8	2 3/4	2 5/8	2 1/2	2 7/16	2 5/16	2 1/4	2 1/8	2 1/16	1 15/16	1 13/16	1 11/16	1 9/16	1 1/2	1 7/16	1 5/16
11	3 1/8	2 15/16	2 13/16	2 5/8	2 9/16	2 1/2	2 3/8	2 5/16	2 3/16	2 1/8	2	1 13/16	1 11/16	1 5/8	1 1/2	1 7/16	1 3/8
12	3 3/16	3 1/8	2 7/8	2 3/4	2 11/16	2 9/16	2 7/16	2 3/8	2 5/16	2 3/16	2 1/16	1 7/8	1 13/16	1 11/16	1 5/8	1 1/2	1 7/16
13	3 1/4	3 3/16	3	2 7/8	2 3/4	2 5/8	2 1/2	2 7/16	2 3/8	2 1/4	2 1/8	1 15/16	1 7/8	1 11/16	1 5/8	1 9/16	1 7/16
14	3 7/16	3 3/16	3 1/8	2 15/16	2 7/8	2 11/16	2 5/8	2 9/16	2 7/16	2 5/16	2 1/8	2	1 7/8	1 13/16	1 11/16	1 9/16	1 1/2
15	3 1/2	3 3/8	3 1/8	2 15/16	2 7/8	2 3/4	2 11/16	2 5/8	2 7/16	2 3/8	2 3/16	2 1/16	1 15/16	1 13/16	1 3/4	1 5/8	1 1/2
16	3 9/16	3 3/8	3 3/16	3 1/8	2 15/16	2 13/16	2 3/4	2 5/8	2 9/16	2 3/8	2 1/4	2 1/8	1 15/16	1 7/8	1 13/16	1 5/8	1 9/16
17	3 5/8	3 7/16	3 5/16	3 3/16	3	2 7/8	2 13/16	2 11/16	2 9/16	2 7/16	2 5/16	2 1/8	2	1 7/8	1 13/16	1 11/16	1 5/8
18	3 11/16	3 1/2	3 3/8	3 3/16	3 1/8	2 15/16	2 13/16	2 3/4	2 5/8	2 9/16	2 5/16	2 1/8	2 1/16	1 15/16	1 7/8	1 3/4	1 5/8

20	3 13/16	3 5/8	3 3/8	3 1/4	3 1/8	3 1/16	2 15/16	2 13/16	2 11/16	2 5/8	2 7/16	2 1/4	2 1/8	2	1 15/16	1 13/16	1 11/16
25	4 1/8	3 13/16	3 5/8	3 1/2	3 7/16	3 5/16	3 3/16	3 1/8	2 15/16	2 7/8	2 5/8	2 7/16	2 5/16	2 1/8	2 1/8	1 15/16	1 13/16
30	4 7/16	4 1/8	3 15/16	3 3/4	3 11/16	3 1/2	3 5/16	3 1/4	3 1/8	3	2 7/8	2 9/16	2 7/16	2 5/16	2 3/16	2 1/16	1 15/16
35	4 9/16	4 5/16	4 1/8	3 15/16	3 3/4	3 5/8	3 9/16	3 7/16	3 5/16	3 3/16	2 15/16	2 11/16	2 9/16	2 7/16	2 5/16	2 1/8	2 1/16
40	5 1/8	4 9/16	4 1/4	4 1/8	3 7/8	3 7/8	3 11/16	3 1/2	3 7/16	3 5/16	3 3/16	2 15/16	2 11/16	2 3/16	2 7/16	2 1/4	2 1/8
45	5 3/16	4 7/8	4 1/2	4 1/4	4 1/16	3 15/16	3 3/4	3 3/4	3 5/8	3 7/16	3 3/16	2 15/16	2 3/4	2 5/8	2 1/2	2 3/8	2 3/16
50	5 1/4	4 15/16	4 5/8	4 7/16	4 1/4	4 1/16	4	3 13/16	3 11/16	3 1/2	3 5/16	3 1/8	2 15/16	2 11/16	2 5/8	2 7/16	2 1/4
55	5 3/8	5 1/8	4 7/8	4 5/8	4 3/8	4 1/4	4 1/8	4	3 13/16	3 11/16	3 3/8	3 3/16	3	2 7/8	2 11/16	2 1/2	2 3/8
60	5 5/8	5 1/4	4 15/16	4 3/4	4 1/2	4 3/8	4 1/4	4 1/8	3 15/16	3 3/4	3 1/2	3 1/4	3 1/8	2 7/8	2 3/4	2 9/16	2 7/16
70	5 3/4	5 1/2	5 1/4	5	4 5/8	4 9/16	4 7/16	4 3/8	4 1/4	3 15/16	3 5/8	3 7/16	3 1/4	3 1/8	2 7/8	2 11/16	2 9/16
80	6 1/16	5 3/4	5 1/2	5 1/4	5 1/16	4 15/16	4 3/4	4 1/2	4 3/8	4 1/16	3 13/16	3 9/16	3 7/16	3 1/4	3 1/8	2 7/8	2 11/16
90	6 1/4	6	5 5/8	5 7/16	5 1/4	5 1/8	4 15/16	4 3/4	4 1/2	4 1/4	4	3 3/4	3 1/2	3 5/16	3 3/16	2 15/16	2 3/4
100	6 13/16	6 1/4	5 3/4	5 5/8	5 7/16	5 3/8	5 1/16	4 15/16	4 5/8	4 7/16	4 1/4	3 7/8	3 11/16	3 3/8	3 1/4	3 1/8	2 7/8
120	6 15/16	6 3/4	6 1/4	6	5 3/4	5 11/16	5 7/16	5 1/4	5	4 7/8	4 7/16	4 1/8	3 13/16	3 5/8	3 1/2	3 1/4	3 1/8
140	7 1/2	6 15/16	6 3/4	6 3/8	6 1/16	5 13/16	5 11/16	5 1/2	5 3/8	5	4 5/8	4 1/4	4	3 13/16	3 11/16	3 7/16	3 1/4
160	7 5/8	7 1/4	6 15/16	6 3/4	6 5/16	6 1/8	5 7/8	5 3/4	5 7/16	5 1/4	4 15/16	4 7/16	4 1/4	4	3 13/16	3 9/16	3 5/16
180	8	7 1/2	7 1/8	6 7/8	6 5/8	6 1/4	6 1/8	5 15/16	5 3/4	5 7/16	5 1/8	4 3/4	4 1/2	4 1/4	4	3 3/4	3 1/2
200	8 1/4	7 13/16	7 3/8	7 1/16	6 3/4	6 11/16	6 7/16	6 1/8	5 7/8	5 3/4	5 3/8	4 15/16	4 5/8	4 1/2	4 1/4	3 7/8	3 5/8
250	9	8 1/2	8	7 1/2	7 3/8	7 1/8	6 7/8	6 11/16	6 3/8	6 1/16	5 3/4	5 1/4	5	4 5/8	4 7/16	4 1/8	3 13/16
300	9 1/8	9	8 5/8	8 1/4	7 7/8	7 1/2	7 1/4	7 1/16	6 7/8	6 7/16	6	5 1/2	5 1/4	5	4 3/4	4 7/16	4 1/8
350	10	9 3/8	9	8 1/2	8 3/16	7 15/16	7 1/2	7 3/16	7 1/16	6 7/8	6 7/16	5 3/4	5 7/16	5 5/16	5	4 5/8	4 3/8
400	10 1/2	9 7/8	9 7/16	9	8	8 3/8	8	7 1/2	7 3/8	7 1/8	6 3/4	6 1/8	5 3/4	5 7/16	5 1/4	4 7/8	4 1/2
450	10 3/4	10 1/8	9 13/16	9 1/4	9	8 3/4	8 1/16	8 3/16	7 9/16	7 3/8	6 15/16	6 1/4	6	5 3/4	5 3/8	5 1/16	4 5/8
500	11 5/16	10 1/2	10	9 5/8	9 1/4	9	8 5/8	8 3/8	8	7 1/2	7 1/8	6 3/4	6 3/16	5 3/4	5 9/16	5 1/4	4 7/8
550	11 1/2	10 7/8	10 3/8	10	9 1/2	9 1/4	9	8 7/8	8 1/2	8	7 5/8	6 3/4	6 1/4	6	5 3/4	5 3/8	5
600	11 7/8	11 3/4	10 5/8	10 1/4	9 3/4	9 1/2	9 1/8	8 15/16	8 1/2	8 1/8	7 3/4	7 1/8	6 3/4	6 1/4	5 15/16	5 9/16	5 1/4

Good hammered iron shafts, 4 in. diameter or longer, will transmit about fifty per cent. more power than shown in these tables.

PULLEYS.

Every pulley in a mill should be as light as possible, consistent with the necessary strength, and be in perfect balance. Many of our millers patronize near-by machine shops and foundries for all their work, *where they pay for it by the pound*, and they generally pay for more than they want, and get poorly balanced and badly polished pulleys in the bargain. A number of millers have been much irritated at the superfluous iron they have paid for, and the poor workmanship displayed in the *fitting*. There are now a number of establishments in the country making a specialty of furnishing finely finished pulleys, light in weight, perfect in balance, in either wood, steel, wrought iron or cast-iron, and as their prices are as low as any, it pays to use such pulleys in the fitting of a mill. Makers of special machines, who attain a reputation for their goods, and are careful to have their machines the lightest running possible, fit them with the lightest and best fitted pulleys. It would pay to observe this in all pulleys and gears of a mill. Power would be saved thereby and power costs money.

It is not policy to use heavy "balance" pulleys on shafting for a steady motion, as is often practiced. The balance pulley will be found in the driving wheel of engine, and from that every pulley should be as light as possible and as near same size as possible for the best results from belts and saving of power.

VALUABLE INFORMATION FOR MACHINISTS AND MILL-MEN.

The following rule will prove of much value in computing exact lengths, speed of pulleys and periphery speed of saws in feet per minute:

RULE TO FIND THE CIRCUMFERENCE OF CIRCLES.

Multiply the diameter by 3.1416 and the product will be the circumference.

Circumference of Circles.

D	0 in.		1 in.		2 in.		3 in.		4 in.		5 in.	
Ft.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
				3 1-7		6¼		9⅞	1	9-16	1	3¾
1	3	1⅝	3	4⅝	3	8	3	11	4	2⅛	4	5⅜
2	6	3⅜	6	6½	6	9⅝	7	0¾	7	3⅞	7	7
3	9	5	9	8¼	9	11⅜	10	2½	10	5⅝	10	8¾
4	12	6¾	12	9⅞	13	1	13	4⅛	13	7¼	13	10½
5	15	8½	15	11⅝	16	2¾	16	5¾	16	9	17	0⅛
6	18	10⅛	19	1¼	19	4⅜	19	7½	19	10⅝	20	1⅞
7	21	11⅞	22	3	22	6⅛	22	9¼	23	0⅜	23	2⅛
8	25	1½	25	4⅝	25	7⅞	25	11	26	2⅛	26	5¼
9	28	3¼	28	6⅜	28	9½	29	0⅝	29	3¾	29	7
10	31	5	31	8⅛	31	11¼	32	2⅜	32	5½	32	8⅝
11	34	6⅝	34	9¾	35	0⅞	35	4⅛	35	7¼	35	10⅝
12	37	8⅜	37	11½	38	2⅜	38	5¾	38	8⅞	39	0
13	40	10	41	1⅛	41	4⅜	41	7½	41	10⅝	42	1⅝
14	43	11¾	44	2⅞	44	6	44	9⅛	45	0¼	45	3½
15	47	1½	47	4⅝	47	7¾	47	10⅞	48	2½	48	5⅛
16	50	3⅛	50	6¼	50	9⅝	51	0½	51	3¾	51	6½
17	53	4⅞	53	8	53	11⅛	54	2⅛	54	5⅜	54	8½
18	56	6½	56	9⅝	57	0⅞	57	4	57	7⅛	57	10¼
19	59	8¼	59	11½	60	2½	60	5⅝	60	8¾	60	11⅞
20	62	9⅞	63	1⅛	63	4¼	63	7⅜	63	11½	64	1⅝
21	65	11⅝	66	2¾	66	5⅞	66	9	66	0⅛	57	3⅜
22	69	1⅜	69	4½	69	7⅝	69	10¾	70	1⅞	70	5
23	72	3	72	6⅛	72	9⅜	73	0½	73	3⅝	73	6¾
24	75	4¾	75	7⅞	75	11	76	2⅛	76	5¼	76	8½
25	78	6⅜	78	9½	79	0¾	79	3⅞	79	7⅛	79	11⅛
26	81	8⅛	81	11¼	82	2⅜	82	5¼	82	8⅝	82	11⅞
27	84	9⅞	85	1	85	4¼	85	8⅛	85	11⅜	86	1½
28	87	11½	88	2⅝	88	5¾	88	9	89	0⅛	89	3¼
29	91	1¼	91	4⅜	91	7½	91	10⅝	92	1¾	92	4⅞
30	94	2⅞	94	6	94	9¼	95	0⅜	95	3½	95	6⅝
31	97	4⅝	97	7¾	97	10	98	2	98	5⅛	98	8⅜
32	100	6⅜	100	9½	101	0⅜	101	3¾	101	6⅞	101	10

Rule to find the circumference of circles.—Continued.

6 in.		7 in.		8 in.		9 in.		10 in.		11 in.	
ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
1	6 1/8	1	9	2	1 1/8	2	4 1/4	2	7 3/8	2	10 1/2
4	8 1/2	4	11 5/8	5	2 3/4	5	5 7/8	4	9	6	2 1/4
7	10 1/4	8	1 3/8	8	4 1/2	8	7 5/8	8	10 3/4	9	1 7/8
10	11 7/8	11	3	11	6 1/8	11	9 3/8	12	5 1/2	12	3 5/8
14	1 5/8	14	4 5/8	14	7 7/8	14	11	15	2 1/8	15	5 1/4
17	3 1/4	17	6 3/8	17	9 5/8	18	0 3/4	18	3 7/8	18	7 1/8
20	4 7/8	20	8 1/8	20	11 1/2	21	2 3/8	21	5 1/2	21	8 3/4
23	6 3/4	23	11	24	1 1/8	24	4 1/8	24	7 1/4	24	10 3/8
26	8 3/8	26	11 1/2	27	2 3/4	27	5 3/4	27	9	28	0 1/8
29	10 1/8	30	1 1/4	30	4 3/8	30	7 1/2	30	11 5/8	31	1 3/4
32	11 3/4	33	2 7/8	33	6 1/8	33	9 1/4	34	0 3/8	34	3 1/2
36	1 1/2	36	4 1/2	36	7 3/4	36	10 7/8	37	2 3/4	37	5 1/4
39	3 1/4	39	6 3/8	39	9 1/2	40	0 5/8	40	3 3/4	40	6 7/8
42	4 7/8	42	8	42	11 1/8	43	2 1/4	43	5 1/2	43	8 5/8
45	6 5/8	45	9 3/4	46	0 7/8	46	4	46	7 1/8	46	11 1/4
48	8 1/4	48	11 3/8	49	2 5/8	49	5 3/4	49	8 7/8	50	0
51	10	52	1 1/8	52	4 1/4	52	7 3/8	52	10 1/2	53	1 5/8
54	11 5/8	55	2 7/8	55	6	55	9 1/8	56	0 1/4	56	3 1/2
58	1 3/8	58	4 1/2	58	7 5/8	58	10 3/4	59	2	59	5 1/8
61	3 1/8	61	6 1/4	61	9 1/2	62	0 1/2	62	3 5/8	62	6 3/4
64	4 3/4	64	7 7/8	64	11	65	2 1/4	65	5 3/8	65	8 1/4
67	6 1/2	67	9 5/8	68	0 3/4	68	3 7/8	68	7	68	10 1/4
70	8 1/4	70	11 1/8	71	2 1/2	71	5 5/8	71	8 3/4	71	11 7/8
73	9 7/8	74	1	74	4 1/8	74	7 1/4	74	10 5/8	75	1 5/8
76	11 5/8	77	2 3/4	77	5 7/8	77	9	78	0 1/8	78	3 1/4
80	1 1/4	80	4 3/8	80	7 5/8	80	10 3/4	81	1 7/8	81	5
83	3	83	6 1/8	83	9 1/4	84	0 3/8	84	3 1/2	84	6 5/8
86	4 5/8	86	7 7/8	86	11	87	2 1/8	87	5 1/4	87	8 3/8
89	6 3/8	89	9 1/2	90	0 5/8	90	3 3/4	90	6 7/8	90	11 1/8
92	8 1/8	92	11 1/8	93	3 3/8	93	5 1/2	93	8 5/8	93	11 7/8
95	9 3/4	96	0 7/8	96	4	96	7 1/4	96	0 3/8	97	1 1/2
98	11 1/2	99	2 5/8	99	5 3/4	99	8 7/8	100	10	100	3 1/8
102	1 1/8	102	4 3/8	102	7 1/2	102	10 5/8	103	1 3/4	103	4 7/8

SHORT RULE TO FIND THE AREA OF CIRCLES.—Multiply ½ the circumference by the radius and the product will be the area.

STRENGTH AND TENSION OF IRON.

The breaking strength of good American iron is usually taken at 50,000 lbs. per square inch, with an elongation of 15 per cent. before breaking. It should not *set* under a strain of less than 25,000 lbs. The *proof* strain is 20,000 lbs. per square inch, and beyond this amount iron should *never* be strained in practice.

WEIGHT AND STRENGTH OF SHORT-LINK IRON CHAINS.

"Since each link consists of two thicknesses of bar, it might be supposed that a chain would possess double the strength of a single bar; but the strength of the bar becomes reduced about 3-10 by being formed into links, so that the chain really has but about 7-10 of the strength of two bars. As a thick bar of iron will not sustain as heavy a load in proportion as a thinner one, so, of course, large chains are proportionately weaker than smaller ones. In the following table, 20 tons (gross) per square inch is assumed as the average breaking strain of a single straight bar of ordinary rolled iron 1 inch in diameter; 19 tons, from 1 to 2 in. dia.; and 18 tons, from 2 to 3 in. dia. Deducting 3-10 from each of these, we have as the breaking strain of the two bars composing each link as follows: 14 tons per sq. inch, up to 1 inch in diameter; 13.3 tons, from 1 to 2 in. and 12.6 tons, from 2 to 3 in. diameter; and upon these assumptions the table is based."

TABLE OF WEIGHTS AND STRENGTH OF SHORT-LINK IRON CHAINS.

Diameter of Iron	Average Weight per Foot.	Breaking Strain.	Diameter of Iron.	Average Weight per Foot.	Breaking Strain.
Ins.	Lbs.	Lbs.	Ins.	Lbs.	Lbs.
3-16	.42	1,731	1	10.	49,280
¼	.91	3,069	1-16	11.3	52,790
5-16	1.22	4,794	⅛	12.5	59,226
⅜	1.5	6,922	3-16	14.	65,960
7-16	2.	9,408	¼	15.5	73,114
½	2.5	12,320	⅜	18.5	88,301
9-16	3.2	15,590	½	22.	105,280
⅝	4.1	19,219	⅝	25.5	123,514
11-16	5.	23,274	¾	29.5	143,293
¾	5.8	27,687	⅞	33.5	164,505
13-16	6.6	32,307	2	38.	187,152
⅞	7.7	37,632	¼	48.5	224,448
15-16	8.9	43,277	½	60.	277,088

TABLE OF TRANSMISSION OF POWER BY WIRE ROPES.

Showing necessary size and speed of wheels and rope to obtain any desired amount of power. (Roebling.)

Diameter of Wheel in feet.	No. of Revolutions.	Diameter of Rope.	Horse-Power.	Diameter of Wheel in feet.	No. of Revolutions.	Diameter of Rope.	Horse-Power.
4	80	⅜	3.3	10	80	11.16	58.4
	100	⅜	4.1		100	11.16	73.
	120	⅜	2.		120	11.16	87.6
	140	⅜	5.8		140	11.16	102.2
5	80	7-16	6.9	11	80	11.16	75.5
	100	7-16	8.6		100	11.16	94.4
	120	7-16	10.3		120	11.16	113.3
	140	7-16	12.1		156	11.16	132.1
6	80	½	10.7	12	80	¾	99.3
	100	½	13.4		100	¾	124.1
	120	½	16.1		120	¾	148.9
	140	½	18.7		140	¾	173.7
7	80	9-16	16.9	13	80	¾	122.6
	100	9-16	21.1		100	¾	153.2
	120	9-16	25.3		120	¾	183.9
8	80	⅝	22.	14	80	¾	148.
	100	⅝	27.5		100	⅞	185.
	120	⅝	33.		120	⅞	222.
9	80	⅝	41.5	15	80	⅞	217.
	100	⅝	51.9		100	⅞	259.
	120	⅝	62.2		120	⅞	300.

NOTES ON THE USES OF WIRE ROPE.—Roebling.

Two kinds of wire rope are manufactured. The most pliable variety contains 19 wires in the strand, and is generally used for hoisting and running rope.

For safe working load, allow 1-5 of 1-7 of the ultimate strength, according to speed, so as to get good wear from the rope. Wire rope is as pliable as new hemp rope of the same strength; but the greater the diameter of the sheaves the longer wire rope will last.

Experience has proved that the wear increases with the speed. It is, therefore, better to increase the load than the speed. Wire rope must not be coiled or uncoiled like hemp or manilla—all untwisting or kinking must be avoided.

In no case should galvanized rope be used for running. One day's use scrapes off the zinc coating.

STRENGTH OF MANILLA AND HEMP ROPES.

"The strength of rope is very irregular, much depending on the quality of the fibre used and the solidity in which the rope is put together. For instance, 3¼-inch circumference *soft*-laid rope will not measure over 3-inch circumference *hard*-laid

• "Our tests of the various makes of rope from the manilla fibre show about the following average maximum strength:

3-inch cir.	soft-laid,	7,300 lbs.
3-inch "	medium-laid,	8,000 "
3-inch "	hard-laid,	9,000 "

PRACTICAL CONSIDERATIONS.

First. Do not tax belts by overloading.

Second. Shafting and pulleys should be arranged by a competent machinist or mechanical engineer.

Third. Rules for finding length of belt: "Add the diameter of the two pulleys together, divide the result by two and multiply the quotient by three and one-seventh, then add this product to twice the distance between the center of the shafts."

Fourth. In locating shafts, great care should be taken to secure proper distance. Experts give the following rules: First.—When narrow belts are to be run over small pulleys, fifteen feet is good average, the belt having a sag of one and one-half to two inches.

Second.—For longer belts working on larger pulleys, a distance of twenty to twenty-five feet does well with a sag of four or five inches.

Fifth. The angle of a belt with the floor should not exceed forty-five degrees.

Sixth. The pulley should be a little wider than the belt required for the work.

Seventh. The strongest part of belt leather is the flesh side.

Eighth. Always run the grain (or hair) side on the pulley. The grain side to pulley gives greater driving power, hugs the pulley closer, less liable to slip, and will drive thirty per cent. more than flesh side.

Ninth. Keep your belts free from the accumulation of dust or grease, or oil drippings. They will injure the leather.

Tenth. Keep your belt soft and pliable by using a good belt dressing.

Eleventh. Rule to find the horse-power that any given width of double belt is easily capable of driving.

Multiply the number of square inches covered by the belt on the driven pulley by one and one-half the speed in feet per minute through which the belt moves, and divide the product by 33,000, the quotient will be the horse-power.

Twelfth. To find the width of belt for any given horse-power: Multiply 33,000 by the horse-power required and divide the product first by the length in inches covered by the belt on the driven pulley and again by half the speed of the belt.

Thirteenth. Rule for piecing a belt when pulleys are changed: One and one-half times the difference of the diameter of the pulleys will give the required piece.

Fourteenth. Tighteners.—The tightening pulley is applied to belts for increasing their adhesion to the pulleys, and as this is to fall first on the smaller pulley it is usual to place them on the slack side of the belt, nearer this pulley, in order to increase adhesion as well as the area of contact. It also increases the friction of driving in proportion to the thrusting of the same from the line of its natural curvature.

Fifteenth. Rules for calculating the speed of pulleys:

Problem 1.—The diameter of the driver and driven being given to find the number of revolutions of the driven, Rule: Multiply the diameter of the driver by its number of revolutions, and divide the product by the diameter of the driven; the quotient will be the number of revolutions.

Problem 2.—The diameter and revolutions of the driver being given to find the diameter of the driven, that shall make any given number of revolutions in the same time, Rule: Multiply the diameter of the driver by its number of revolutions and divide the product by the number of revolutions of the driven; the quotient will be the diameter.

Problem 3.—To find the size of the driver. Rule: Multiply the diameter of the driven by the number of revolutions you wish to make and divide the product by the revolutions of the driver; the quotient will be the size of the driver.

RULES FOR ENGINEERS AND FIREMEN ON THE CARE AND MANAGEMENT OF STEAM BOILERS.

The care of steam boilers, and the qualifications of engineers in the management of same, has resulted in a general movement in several States towards requiring engineers to prove themselves competent before being put in charge of steam boilers, and it originates from a desire to grapple with an evil which is a continual source of danger to the people. If steam users could be trusted to employ only competent attendants to their boilers, there would be no necessity for the law infringing their personal liberty so far as to say who shall *not* be left in charge; but unfortunately many steam users are extremely reckless in this matter, as numerous fatal explosions have testified.

The laws that require the examination and license of persons who act as engineers, are enacted for the protection of life and property, from loss or damage, by the explosion of boilers or tanks under pressure. Hence it follows that the law-makers had no intent to provide that the license should be evidence of the skill of the holder as an engineer; that is a matter that only concerns his employer. The State deals only with that which threatens the safety of persons or communities. The license is only evidence that the person to whom it is issued can care for and run safely a steam boiler. That is as far as the State can go without interfering with the rights of individuals. It is no affair of the State, does not concern it to know or certify that a man can adjust or set valves, can take down or erect an engine, produce power with the least consumption of fuel, or be able to use the indicator intelligently; these are all matters that concern only the steam user. But when the use and safety of a boiler is considered, the State has the undoubted right to say that the person who is to take charge of this dangerous device shall possess sufficient skill and experience to insure safety for operators in the mill, also for citizens living in the vicinity. It follows, then, that the examination for license can only refer to the boiler and the appliances that will insure its safety.

Every engineer and fireman ought to know perfectly well, without the necessity of any elaborate calculations or theorizing, what results will ensue should he overload his steam engine, his boiler, or any of the machinery under his charge, and he would not be compelled to call in the services of some expert engineer to tell him clearly and concisely what would occur under such conditions. He would know that in the vast majority of cases he would be subjecting himself to the possibility—in fact, high probability—of a speedy break-down, and, before that event actually transpired, to endless trouble of every description, all the result of poor judgment, or unfortunate necessity, which led him to work his boiler, engine or machinery up to double, or perhaps treble, what it was intended for.

Every applicant for an engineer's license should be prepared to answer all questions that will show that he is mentally well equipped to provide against possible disaster. He should be well skilled in the construction, care and manipulation of pumps, injectors, inspirators, all the devices by which the boiler is supplied with water. He should be familiar with the use of the gauges in use for determining pressure of steam, or the quantity of water in the boiler. The safety-valve should be under his care, always ready to perform its functions. Then he should have some idea of the difference between fibrous and crystallized iron; should be able to tell when a boiler had become weak, needed repairs and have the courage to say so, and refuse to fire it. He should have skill sufficient to enable him to frequently inspect the boiler, and determine if the factor of safety is enough to insure absolute safety. He should be able to take such care of the boiler that large or dangerous deposits of scale or mud are not possible; also, should know what to do when "priming" or "foaming" is evident. He should inform himself as to the effects of corrosion, internal scale and deposits, improper setting, impeded circulation and improper steam and water connections.

HINTS TO ENGINEERS.

There are engineers and engineers—one may be dear at $18 per week, another cheap at $25 per week. This point will be best appreciated by those who are most conversant with the subject. Having spent thousands of dollars in buildings, and fitting up a mill or factory with modern machinery adapted to your business, is it good management to intrust its care to the cheapest engineer you can obtain?

Instances of this kind are of almost daily occurrence; many result very disastrously. Most of them are such expensive experiments that they are never repeated by the same party. Within certain well-defined limits the best is the cheapest. Don't let a few dollars prevent your employing the most competent man, one who, knowing his ability and experience, may seem to you to be too high priced.

We are often reminded that all things constructed by human hands are imperfect; those imperfections increase with age and use. It would effect an important saving in repairs, with greatly increased efficiency and durability of machinery and tools, if regular days—if possible, twice in each year, the time regulated by the dull season of the particular business in which you are engaged, when the machinery should be stopped and needful repairs, alterations and improvements be made.

There may be, perhaps, many engineers who do not desire any information on the care of boilers, while others are only too glad to receive it. The former might decline to gratify the less experienced by imparting knowledge for the benefit of others, and some refrain from asking questions for fear of showing their inexperience. Such considerations should not weigh where men desire to advance themselves.

A poorly constructed boiler in charge of an intelligent engineer is safer with eighty pounds of steam than a well-constructed boiler in the hands of a reckless and ignorant man is with forty pounds!

Many defects in boilers can be attributed to the want of care on the part of the engineer.

A boiler should be washed at least once a month, removing all hand-hole and man-hole plates, freeing the legs of dirt and sediment, being particular about the back leg, if the boiler is of the locomotive style; should there be no hand-hole, then have one put in as soon as possible. Examine the boiler inside, and be sure that no braces are out of place and no pins backed out. Take the grate bars out and paint the legs with red-lead and oil; this will prevent scales or dirt from forming on the outside.

All water used for wetting ashes, also the leader from gauge-cocks dripping in ash-pan, has a tendency to weaken the legs by corrosion to a great extent.

Before letting cold water in after blowing out a boiler, allow two hours, at least, for a contraction to take place slowly.

In replacing the hand-hole plates be sure the gaskets are properly fitted, cutting off all overhanging edges; also whitelead the plate so the gasket will hold to it. This will prevent the use of new gaskets every time the plates are taken out.

In setting up the plate, use an ordinary screw-wrench, and see that the crow-feet do not bring up on the plate. A six-foot wrench will not make the plate tight if not properly replaced.

Never force fires in getting up steam from cold water. Slow fires are best.

Do not make a race between fire and iron to see which is the most durable.

A good engineer will not brag on getting up steam from cold water in twenty minutes.

Remember! the steam boiler is a good servant in the hands of an intelligent master.

Do not condemn any appliance introduced ostensibly for the purpose of securing economy or safety without giving it a fair trial, as some of the most valuable inventions now in use were ridiculed and rejected when first introduced. Many excellent "devices" have been condemned by those having the care of them, and replaced by others at great expense to the owners of boilers and engines.

Do not discountenance any device, invention, adjunct or arrangement that will lessen your labor, induce economy, and at the same time give a guarantee of safety. Give everything placed in your charge by your employer a fair, impartial trial.

Do not allow the boiler-head to become filthy or the gauge-cocks to leak and become covered with mud and the salts resulting from impurities in the water, as this would furnish strong evidence of slovenliness.

Do not let anything connected with the boiler in your charge run from bad to worse, with the idea that at some certain time you will have a general overhauling and repairing, because an accident may occur at any moment, involving serious loss of life and property.

Do not neglect to have the boiler insured when practicable, as insurance is generally accompanied by intelligent inspection, which furnishes a guarantee of safety to the engineer, owner or steam user.

Do not reject the advice or suggestions of intelligent boiler inspectors, as their experience enables them to discriminate in cases which never come under the observation of persons of a different calling or pursuit.

THE FOLLOWING RULES FOR ENGINEERS AND FIREMEN HAVE BEEN ADOPTED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

1. CONDITION OF WATER.—The first duty of an engineer when he enters his boiler-room in the morning is to ascertain how many gauges of water there are in his boilers. *Never unbank nor replenish the fires until this is done.* Accidents have occurred, and many boilers have been entirely ruined from neglect of this precaution.

2. LOW WATER.—In case of low water, immediately cover the fires with ashes, or, if no ashes are at hand, use *fresh coal.* Don't turn on the feed under any circumstances, nor tamper with, or open the safety-valve. Let the steam outlets remain as they are.

3. IN CASES OF FOAMING.—Close throttle, and keep closed long enough to show true level of water. If that level is sufficiently high, feeding and blowing will usually suffice to correct the evil. In cases of violent foaming, caused by dirty water, or change from salt to fresh, or *vice versa,* in addition to the action above stated, check draft and cover fires with fresh coal.

4. LEAKS.—When leaks are discovered they should be repaired as soon as possible.

5. BLOWING OFF.—Blow down, under a pressure *not exceeding* 10 pounds. Where surface blow-cocks are used, they should be often opened for a few moments at a time. The blow-off-valve should be opened wide once a day, oftener if the water contains much sediment. The time required to open wide and close the valve is long enough.

6. FILLING UP THE BOILER.—After blowing down *allow the boiler to become cool* before filling again. Cold water, pumped into hot boilers, is very injurious from sudden contraction.

7. EXTERIOR OF BOILER.—Care should be taken that no water comes in contact with the exterior of the boiler, either from leaky joints or other causes.

8. REMOVING DEPOSIT AND SEDIMENT.—In tubular boilers the hand-holes should be often opened, and all collections removed from over the fire. Also, when boilers are fed in front and blown off through the same pipe, the collection of mud or sediment in the rear end should be often removed.

9. SAFETY-VALVES.—Raise the safety-valves cautiously and frequently, as they are liable to become fast in their seats, and useless for the purpose intended.

10. SAFETY-VALVES AND PRESSURE GAUGE.—Should the gauge at any time indicate the limit of pressure allowed, see that the safety-valves are blowing off.

11. GAUGE-COCKS. GLASS GAUGE.—Keep gauge-cocks clear and in constant use. Glass gauges should not be relied on altogether.

12. BLISTERS.—When a blister appears there must be no delay in having it carefully examined, and *trimmed* or *patched* as the case may require.

13. CLEAN SHEETS.—Particular care should be taken to keep sheets and parts of boilers exposed to the fire perfectly clean, also all tubes, flues and connections well swept. This is particularly necessary where wood or soft coal is used for fuel.

14. GENERAL CARE OF BOILERS AND CONNECTIONS.—Under all circumstances keep the gauges, cocks, etc., clean and in good order, and things generally in and about the engine and boiler-room in a neat condition.

The foregoing Rules and Hints to Engineers should be referred to daily.

By their careful observance, economy of fuel and the durability and safety of the boiler are attained. Through their neglect, waste, frequent and expensive repairs and danger are the certain results. These considerations are important, and should not be lost sight of. Boilers are expensive to buy and run, and it would seem natural that owners should strive by proper care to make the other expenses attending their use as small as possible. That this in too many instances is not done is very evident, and those at fault pay well for their neglect. There is another important fact to be considered, however, and that is, that want of care is the cause of explosion. There is no mystery about it, and no man has the right to imperil the lives and property of others by his carelessness. In running steam boilers it would be well to

Remember that it is no excuse for an engineer or fireman not to improve himself in the duties of his calling, because his present situation is not agreeable or his pay not remunerative, or his employer does not treat him kindly. Such circumstances should stimulate him in his efforts to acquire knowledge, instead of causing him to become a laggard, as his opportunity will undoubtedly come, and how can he expect to make a better change, or get a better position unless he prepares himself beforehand to fill it, and also to

Remember that it is absurd for an engineer or fireman to expect to fill a good position, command good wages, and secure the confidence and respect of his employers, unless he can show that he has made the object of his calling the subject of investigation and study. There are thousands who are always ready and willing to fill good positions, if they could be only accorded a short time to prepare themselves, which of course would be impracticable and unreasonable.

With a knowledge of the foregoing requisites for the safety of steam boilers an engineer should be familiar, and examiners will do well to see that those who procure license to care for boilers, have the knowledge to exercise that care, with every assurance of safety for those whose business or necessities require them to work, dwell or visit in the vicinity of these dangerous store-houses of potential energy.

TESTING STEAM BOILERS.

Every steam boiler, for whatever purpose employed, ought to be opened, cleaned, thoroughly examined and tested at least once a year. The sound *test* is the most reliable in cases where it can be applied as the eye and the ear can be employed to discover the character and occasion of those defects, which the sound of the hammer, when brought in contact with the material, discloses. The hydraulic test can be employed in cases where it would be impossible to attempt the sound test, and is of great value when intelligently applied; but its application should be under the control of intelligent persons, as a reckless use of the hydraulic test may result in injury to the boiler, as it doubtless has ruined a good many.

EXTERNAL CORROSION.

All boilers should be *arched* over, allowing at least fifteen to twenty inches space between the boiler and brick-work. This will protect them from any external corrosion from valves, flange joints or any other leakage over the boiler, and any leaks from the shell of the boiler can be seen by looking under the arch. The arching will have a great tendency to dry the steam. No ashes or lime should be kept next the boiler, where the water from leakages from steam pipes would fall on it and form a lye which would corrode the iron.

SCALE AND CORROSION IN BOILERS.

We find that there are very few steam users, or even those placed in charge of the steam boiler, as engineer, who fully understands the great danger of running steam boilers without proper care. In our experience as boiler inspectors, we have very frequently found boilers in which the iron had wasted away two-thirds of its original thickness from corrosion, and even the rivet-heads in whole seams had disappeared, leaving no margin of safety. In most cases this danger is not seen, even in a close inspection of the boilers, unless the engineer or inspector understands his business thoroughly, as the iron is covered by a crust or scale, probably of sufficient thickness to cause a weakness of the iron plate, even if it was not affected otherwise. This agent of destruction in a boiler, called corrosion, invariably eats away the iron more rapidly when covered over by a non-conducting boiler scale. If no scale existed the action of the water would come in direct contact with the iron, and would, to some extent, prevent the corrosive action.

Almost every engineer has his own remedy for boiler scale; among which may be mentioned slippery-elm, flax-seed, bass-wood, oak blocks, witch-hazel, coal-oil, buckwheat, Indian meal, saw-dust, molasses, galvanic batteries and boiler fluids.

But an article manufactured by G. W. Lord, Philadelphia, Pa., known as Lord's Boiler Compound, appears to be the only chemical preparation in use, at the present day, that will prevent the formation of scale, or not, soften and remove it after it has been formed, in any class of boilers, without more or less injury to the iron, as it neutralizes the action of the natural chemical salts which form the basis of all scale and incrustation.

We also find this article unanimously endorsed by authors of mechanical books, engineers in charge of works, practical chemists and men having large capital invested in steam boilers, as a remedy for corrosion, such as pitting and wasting of iron, which causes so many explosions. And we must bear in mind that this trouble, at least, cannot possibly be overcome by any mechanical means.

DIRECTIONS FOR SETTING UP PUMPS.

Never use pipes of a smaller size than given in the tables; when long pipes are used, it is necessary to increase the diameter to allow for the increased friction, especially in regard to suction pipes.

Use as few turns and angles on pipes as possible, and run every pipe in as direct a line as practicable. Bends, returns and angles increase friction more rapidly than length of pipe.

See to it that the pump has a full supply of water.

In pumping very hot water, always flood your pump by placing it so that it will be supplied from a head.

A gallon of water (U. S. standard) weighs $8\frac{1}{3}$ pounds, and contains 231 cubic inches.

A cubic foot of water weighs $62\frac{1}{2}$ pounds, and contains 1,728 cubic inches, or $7\frac{1}{2}$ gallons.

Doubling the diameter of a pipe increases its capacity four times.

Friction of liquids in pipes increases as the square of the velocity.

Each nominal horse-power of boilers requires 30 to 35 pounds of water per hour.

To find the area of a piston, square the diameter and multiply by .7854.

To find the pressure in pounds per square inch of a column of water, multiply the height of the column in feet by .434.

To find the capacity of a cylinder in gallons, multiply the area in inches by the length of stroke in inches will give the total number of cubic inches; divide this amount by 231 (which is the cubical contents of a gallon in inches), and product is the capacity in gallons.

Ordinary speed to run pumps is 100 feet of piston per minute.

To find quantity of water elevated in one minute running at 100 feet of piston per minute, square the diameter of water cylinder in inches and multiply by 4. Example: Capacity of a five-inch cylinder is desired. The square of the diameter (5 inches) is 25, which, multiplied by 4, gives 100, which is gallons per minute (approximately).

To find the horse-power necessary to elevate water to a given height, multiply the total weight of column of water in pounds by the velocity per minute in feet, and divide the product by 33,000 (an allowance of twenty-five per cent. should be added for friction, etc.).

INSTRUCTIONS TO ENGINEERS.

GETTING UP STEAM.—Before lighting the fire in the morning, raise your safety valve, brushing away all the ashes and dust which may impair its free action, and if it leaks steam grind it on its seat with fine emery or grindstone grit. Valves with vibratory stems are safer than those with rigid stems, as they are not so liable to bind by the lever and weight getting out of true. To guard against loss by leakage and evaporation, leave the water up to the third gauge at night and keep it up to the second gauge during working hours. Clean all ashes and cinders from the furnace and ash-pit, and spread a layer of two or three inches of coal over the grate bars; pile on plenty of shavings over the coal, with dry sawdust, split wood, etc., then start your fire. Keep the fire even and regular over the grate-bars, about 5 inches thick with soft coal, and about 3 inches with anthracite, and always avoid excessive firing. Moderate charges or firings at intervals of 15 to 20 minutes give the best results. In getting up steam from *cold* water the fire should be raised gradually, to avoid damaging the boiler by unequal expansion of the iron. Do not keep the damper and furnace door open at the same time, as the extreme draught expels the heat from the furnace into the chimney, and the cold air entering through the door induces a damaging contraction of the boiler plates wherever it strikes. The current of air enters the ash-pit with a velocity of 12 feet per second, and every 100 lbs. of coal requires about 15.525 cubic feet for its combustion. With *wood* for fuel, the area of grate surface should be 1.25 to 1.4 that for coal. Volume of furnace for *coal* burning should be from 2.75 to 3 cubic feet for every square foot of its grate surface, for *wood* 4.6 to 5 cubic feet. The use of the pyrometer has satisfactorily established the following facts: 1st, That the admission of a certain quantity of air behind the bridge develops a greater amount of heat for raising steam by assisting combustion and consuming the smoke, the existence of smoke being always a sure sign of waste. 2. A regular continuous supply of air to the furnace increases its heating powers 33½ per cent. 3. The supply of air may enter behind the bridge, through the bars, or through the furnace doors, as long as it is properly regulated. 4. The supply of air may vary with the nature of the fuel; light burning coal requiring less air than caking coal, because the latter becomes a compact mass in the furnace, excluding the air from the bars, while the latter is the reverse. 5. For perfect combustion a high temperature is necessary. In all cases see that the bars are well covered and the fuel kept from caking. Knock away the clinkers as soon as formed, keeping the spaces open between the bars. Regulate the supply of air either by the dampers, ash-pit, furnace doors or by an orifice behind the bridge. A jet of steam from a pipe placed across the top of, and inside the door, will greatly assist in consuming the smoke and intensifying the heat, by yielding up its oxygen and hydrogen.

If steam commences to blow off at the safety-valve while the engine is at rest, start your pump or injector to create a circulation, cover or bank your fire with a charge of ashes or fresh coal to absorb the heat, and allow the steam to have free egress through the safety-valve. If by neglect the water gets very low, and the boiler dangerously hot, the fire should either be drawn or drenched with water. Should the fire be very hot and the water supply temporarily cut off, stop the engine and cover the fire quite thickly with fresh fuel to absorb the heat, keeping the usual allowance of water in the boiler until the supply is renewed. Boilers should be blown out every two or three weeks, or as often as mud appears in the water, but never until after the fire has been drawn at least one hour, and the damper closed, otherwise the empty boiler might be damaged by the heat. Never fill a *hot* boiler with *cold* water, as the sudden contraction many times repeated will eventually cause it to leak. Never blow out a boiler with a higher pressure than 50 lbs. to the square inch, as steam at a high pressure indicates a high temperature in the iron, which under careful management should be always let down gradually. Previous to filling a boiler, raise the valve to permit the free egress of the air which might otherwise do manifold damage.

Use every possible precaution against using foul water, as it induces foaming in the boiler; soapy or oily substances and an insufficiency of steam room have a like effect, causing the boiler to burn on the spots where the water is lifted from it, and the glass gauges to indicate falsely, besides damaging the cylinder by priming, carrying mud, grit, water and slush into it through the pipe, and rendering the cylinder-heads liable to be knocked out. Steam from pure water at 212° Fahr. supports a 30-inch column of mercury. Steam from sea, or impure water at the same temperature, will support only 22 inches.

Pure soft water derived from lakes and large streams, rain-water from cisterns, reservoirs, etc., and springs *outside of limestone districts*, is the best for steam purposes. Water from wells and springs *in limestone districts* and small streams hold in solution large quantities of chloride of sodium, carbonate of lime, sulphate of lime, etc., besides quantities of vegetable matter in suspension. The carbonic acid in the water, which holds the carbonate of lime, etc., in solution, being driven off by boiling, the latter is precipitated and forms an incrustation which adheres with obstinate tenacity to the boiler-plates. By continual accretion the deposit of scale becomes thicker and thicker, and being a non-conductor of heat it requires 60 per cent. more fuel to raise the water to any given temperature when the scale is ¼ of an inch thick; the conducting power of scale compared with that of iron being as 1 to 37. The red scale formed from water impregnated with salts of iron, derived from percolation through iron ore, is still more destructive to steam boilers, and in no way can the evil be completely averted except by the use of chemicals, which will neutralize the different corrosive impurities of water.

In tubular boilers, the hand-hole should be opened frequently and all sediment removed from over the fire; keep the sheets, flues, tubes, gauge-cocks, glass gauges and connections well swept and perfectly clean, and the boiler and engine-room in neat condition. Keep a sharp lookout for leaks, and repair them if possible without delay, and allow no water to come in contact with the exterior of the boiler under any circumstances. Examine and repair every blister as soon as it appears, and make frequent and thorough examinations of the boiler with a small steel hammer.

In case of foaming, close the throttle, and keep closed long enough to show true level of water. If the water level is right, feeding and blowing will generally stop the trouble. With muddy water it is a safe rule to blow out 6 or 8 inches every day. If foaming is violent from dirty water, or change from salt to fresh, or from fresh to salt, in addition to following the above directions, check draught and cover the fire with ashes or fresh fuel.

Great watchfulness is necessary when steam is raised, the safety-valve fixed, the fire strong and the engine at rest. In every case there is a rapid and dangerous absorption of heat, the temperature, latent and sensible heat included, often rising to 1200° Fahr. Frequently it is but the work of an instant to convert the latent into sensible heat, thus generating an irresistible force which bursts the boiler and destroys life and property. The destruction generally coming at the moment of starting the engine, the opening of the valve inducing a commotion in the water, which flashes into steam the instant it touches the heated plates. Steam has been known to rise from a pressure of 32 lbs. to the square inch to 90 lbs. to the square inch, in the short space of *seven* minutes, with the engine at rest. It ought to quicken the vigilance of every engineer to know that the explosive energy in each and every cubic foot of water in his boiler at 60 lbs. pressure, is equal to that contained in 1 lb. of gunpowder.

From avaricious motives it has become quite common to discharge, or to decline to employ, qualified and careful engineers. Incompetent men are employed because their labor costs a few dollars less than that of the former. This is too much of a bad thing to pass over without notice. Employ good skilful men in the management of steam power, or employ none at all, and pay them decent wages. If an oversight takes place, and the best and most careful men are liable to make mistakes, never scold, reprimand or exact service during dangerous emergencies, as in the event of lost water in the boiler. In no case risk life, limb or property, and do not let the consideration of saving a few dollars debar you from securing intelligent assistants. The Turkish mode of driving business on a late occasion was to discharge the English engineers who brought out the war vessels which were built in England, and supply the vacancies by installing cheap, green hands. After getting up steam the new "Chief" proceeded to start the engines. A lift at a crank produced no results, a pull at a lever was equally useless. At length the illustrious official espied a bright brass cock, and thinking he had got hold of a sure thing this time, proceeded to give it a twist, when he was suddenly saluted with a jet of steam full in the face, which swept the "engineer" and his assistants out of the engine-room, into the fire-room down-stairs. So much for cheap labor and the consequent results.

PREVENTION OF BOILER SCALE.

The scale in boilers is formed from impurities of the water, and if pure water only is fed into the boiler, no scale is formed. This being settled beyond doubt, many methods have been proposed to purify the feed water in a rapid and cheap manner. To prevent scale by the use of calcium hydrate and soda, F. Scheukel employs one or more tanks, according to the supply needed for the works, in which the water from the river is purified, and another tank for the purified feed-water. As purifying tanks he uses four iron boxes (or cylinders of old steam boilers), not over 5 feet high, which have an outlet cock about 6 inches above the bottom. They are heated by steam to 60° at least, and are preferable surrounded by some non-conducting material. Besides, they are furnished with a stirring arrangement, preferable a Koerting steam-jet stirrer.

The pure water tank is placed on a level below the purifying tank, so that the purified water can flow directly into it from the purifying tanks, without the use of a pump. The water in the purifying tanks is heated as much as possible and the required quantity of thin milk of lime added and stirred; this quantity being either calculated after the analysis of water or ascertained by experiment. Only so much lime is to be added that red litmus paper dipped into the water, after 15 to 20 seconds begins to turn blue. Then the calculated quantity of pure (96 to 98 per cent.) soda dissolved in hot water is added, stirred, and the water allowed to settle. In 20 to 30 minutes the precipitate formed is thrown down in large flakes and the perfectly clear water is drawn off into the feed-water tank. With ammonium oxalate it must not give any turbidity; and if another sample taken becomes turbid on the addition of calcium chloride, too much soda has been used. The advantages of this method of purifying the feed-water are: That the boiler requires no cleaning for a whole season; that the iron of the boiler-walls is not attacked; that the water does not froth and stop up the gauge-cocks, etc; that the steam is free from acid; that steam is easier generated and thereby fuel is saved; that no breaking out of scale is required, its cost saved and the interruption of work caused thereby is avoided; that, finally, the method is comparatively inexpensive.

The purification of water by milk of lime and soda is known, but as regards the practical application, the above communication is valuable. The "Pharm Centralhalle," however, remarks that soda is not the cheapest purifier for all calcareous water, but for such as contain considerable proportions of calcium nitrate; besides gypsum, barium chloride would be cheaper to employ.

ON THE FORM, STRENGTH, ETC., OF STEAM BOILERS.

Regarding the *form* of boilers it is now an ascertained fact that the maximum strength is obtained by adopting the cylindrical or circular form, the haycock, hemispherical, and wagon-shaped boilers, so general at one time, have now deservedly gone almost out of use. Good boiler plate is capable of withstanding a tensile strain of 50,000 lbs., or 60,000 lbs., on every square inch of section; but it will only bear a third of this strain without permanent derangement of structure, and 40,000 lbs., or 30,000 lbs., even, upon the square inch, is a preferable proportion. It has been found that the tenacity of boiler-plate increases with the temperature up to 570°, at which point the tenacity commences to diminish. At 32° cohesive force of a square inch of section was 56,000 lbs.; at 570° it was 66,500 lbs.; at 720°, 55,000 lbs.; at 1050°, 32,000 lbs.; at 1240°, 22,000 lbs.; and at 1317°, 9,000 lbs. Strips of iron, when cut in the direction of the fibre, were found by experiment to be 6 per cent. stronger than when cut across the grain. The strength of riveted joints has also been demonstrated by tearing them directly asunder. In two different kinds of joints, double and single riveted, the strength was found to be, in the ratio of the plate, as the numbers 100, 70 and 56.

Assuming the strength of the plate to be - - 100

The strength of a double riveted joint would be, after allowing for the adhesion of the surfaces of the plate - - - - - - - 70

And the strength of a single riveted joint - - 56

These figures, representing the relative strengths of plates and joints in vessels required to be steam and water tight, may be safely relied on as perfectly correct. The accidental overheating of a boiler has been found to reduce the ultimate or maximum strength of the plates from 65,000 to 45,000 lbs. per square inch of section. Every description of boiler used in manufactories or on board of steamers should be constructed to a bursting pressure of 400 to 500 lbs. on the square inch; and locomotive boilers, which are subject to much harder duty, to a bursting pressure of 600 to 700 lbs. Such boilers are usually worked at 90 to 110 lbs., on the inch, but are frequently worked up to a pressure of 120, and, when rising steep grades sometimes even as high as 200 lbs., to the square inch. In a boiler subject to such an enormous working pressure, it requires the utmost care and attention on the part of the engineer to satisfy himself that the flat surfaces of the fire box are capable of resisting that pressure, and that every part of the boiler is so nearly balanced in its powers of resistance as that, when one part is at the point of rupture, every other part is at the point of yielding to the same uniform force: for we find that, taking a locomotive boiler of the usual size, even with a pressure of 100 lbs., on the square inch, it retains an expanding force within its interior of nearly 60,000 tons, which is rather increased than diminished at a high speed. To show the strain upon a high-pressure boiler, 30 feet long, 6 feet diameter, having two centre flues, each 2 feet 3 inches diameter, working at a pressure of 50 lbs., on the square inch, we have only to multiply the number of the square feet of surface, 1030, exposed to pressure, by 321, and we have the force of 3319 tons, which such a boiler has to sustain. To go farther, and estimate the pressure at 450 lbs., on the square inch, which a well-constructed boiler of this size will bear before it bursts, and we have the enormous force of 29,871, or nearly 30,000 tons, bottled up within a cylinder 30 feet long and 6 feet diameter. Boilers in actual use should be tested at least once a year, by forcing water into them by the hand-feed pump, until the safety-valve is lifted, which should be loaded with at least twice the working pressure for the occasion. If a boiler will not stand this pressure it is not safe, and either its strength should be increased or the working pressure should be diminished. Internal flues, such as contain the furnace in the interior of the boiler, should be kept as near as possible to the cylindrical form; and, as wrought iron will yield to a force tending to crush it about one-half of what would tear it asunder, the flues should in no case exceed one-half the diameter of the boiler, with the same thickness of plates they may be considered equally safe with the other parts. The force of compression being so different from that of tension, greater safety would be ensured if the diameter of the internal flues were in the ratio 1 to 2½ instead of 1 to 3 of the diameter of the boiler. As regards the relative size and strength of flues, it may be stated that a circular flue 18 inches in diameter will resist double the pressure of one 3 feet in diameter. Mill owners, with plenty of room and a limited experience with steam power, would do well to dispense with boilers containing many flues, the expense is greater and the durability less than where there is one or two only. The foam caused by a large number of flues is apt to deceive an inexperienced engineer, causing him to believe that there is plenty of water in the boiler when he tries the gauge cock, when there is but very little, often causing an explosion. Some mill-owners insert a fusible plug in the crown of the furnace to indicate danger from low water. As common lead melts at 620°, a rivet of this metal 1 inch in diameter, inserted immediately over the fire place, will give due notice, so that relief may be obtained before the internal pressure of the steam exceeds that of the resisting power of the heated plates. In France, an extensive use is made of fusible metal plates, generally covered by a perforated metallic disc, which protects the alloy of which the plate is composed, and allows it to ooze through as soon as the steam has attained the temperature necessary to insure the fusion of the plate, which varies from 280° to 350°. The reader will find a number of such alloys under the tabular view of alloys and their melting heats, further on. Another method is the bursting plate, fixed in a frame and attached to some convenient part of the upper side of the boiler, of such thickness and ductility as to cause rupture when the pressure exceeds that on the safety valve. But, beyond all question, constant use should be made on all boilers of a good and reliable system of steam gauges, glass tubes, gauge cocks, safety valves, etc. By means of the glass tubes affixed to the fronts of the boilers, the height of the water within the boiler is indicated at once, for the water will stand at the same height in the tube that it stands in the boiler, communication being established with the water below and the steam above, by means of stop cocks.

When dry steam is an object, the use of the steam dome on boilers is strongly recommended; opinions are divided as to the real value of mud drums, some reason strongly in their favor while others discard them entirely; but there can be no question as to the true economy of heating the feed water previous to emission into the boiler; it should always be done when practicable to do so, by means of some one of the many contrivances for that purpose which are now in the market. Regarding the *power* of boilers, it may be stated that a boiler 30 feet long and 3 feet in diameter, will afford 30x3x3.14x2—141.30 square feet of surface, or steam for 14 horse-power, if 10 feet are assumed for one horse-power. Two short boilers are preferable to one long one, on account of having more fire surface,—it being always necessary to have as much fire surface as possible to make the best use of the fuel—as the hotter the surface is kept, the less fuel it takes to do the same amount of work. When there is a large furnace it gives the fireman a better chance to keep the steam regular, for when clearing out one part of the furnace, he can keep a hot fire in the other. For each horse-power of the engine there ought to be at least one square foot of grate, and three feet would be better. In setting a boiler. arrangement should be made to carry on combustion with the greatest possible heat. This requires good non-conductors of heat, such as brick, with which to surround the fire. If these bricks are of a white color, the combustion is more perfect than if of a dark color. The roof, as well as the sides of the furnace, should be of white fire-brick. The bars of the furnace should be 18 or 20 inches below the boiler or crown of the furnace. They should slope downward toward the back part, about half an inch to the foot. A crack in a boiler plate may be closed by boring holes in the direction of the crack and inserting rivets with large heads, so as to cover up the imperfection. If the top of the furnace be bent down, from the boiler having been accidentally allowed to get short of water, it may be set up again by a screw-jack, a fire of wood having been previously made beneath the injured plate; but it will in general be nearly as expeditious a course to remove the plate and introduce a new one, and the result will be more satisfactory. There is one object that requires very particular attention, and which must be of a certain size to produce the best effect, and that is the flue leading from the boiler to the chimney, as well as the size and elevation of the chimney itself. Every chimney should be built several feet above the mill house, so that there is no obstruction to break the air from the top of the chimney. In England a factory chimney suitable for a 20 horse-power boiler is commonly made about 20 inches square inside, and 80 feet high and these dimensions are correct for consumption of 15 lbs. coal per horse-power per hour, a common consumption for factory engines. In the dominion of Canada and the United States, chimneys of sheet iron, from 30 to 50 feet high, are in quite common use by owners of saw, and other mills, and they seem to answer every requirement.

DON'T DO THESE THINGS.

Don't open a cock or a valve under pressure, and let steam into cold pipes suddenly. If you do there will be a bill of repairs to pay, to say nothing of the liability of killing or maiming someone for life. A man was employed in a brewery cleaning barrels with steam from the boiler. He opened the globe valve suddenly and blew up the barrel, losing one arm by his imprudence.

Don't suppose that a safety valve is going to think for itself, and don't fancy it is all right because it was tried last month, or last year, perhaps. Try the safety valve daily, and examine it, so as to be sure that the stem is not bent, or that the weight has not been shifted by accident or design.

Don't omit to keep the water gauge in good order, and be sure that the openings into the boiler, both steam and water, are not stopped up partially by scale or something lodged in them. Where the openings are of different sizes the water level will not show properly. Test the gauge by the gauge cocks, and be sure that it is right.

Don't suppose that the boiler is all right internally because it has never blown up yet. Get into it, and see whether it is or not. The man-hole plate ought to come off every week, and the engineer should satisfy himself by inspection that the braces are all right.

Don't forget that the blow cock is a thief which is very apt to run away with a great deal of coal unless it is tight. It should not leak a drop.

Don't be too liberal with oil or fat in the cylinder. Some men are constantly slushing the cylinder with grease, under the impression that it makes the engine run easier. After one or two revolutions all the grease that does not cover the rolls of the cylinder is carried out with the exhaust and scattered over the surrounding country. On a wooden roof this invites fire, and on a metal roof it soon causes leak by corrosion, for fatty acids are the most active of corrosive agents. Use sight feed cups in preference to any other agents; they not only save attendance, but they feed oil as it is needed—drop by drop.

Do not start up an engine in the morning under full head, or you will have a cylinder head or some joints blown out.

WEIGHT OF WROUGHT IRON.

Thickness in	Weight of a Sq. Ft.	Weight per Ft. Sq Bar.	Weight per Ft. Rd. Bar.	Thickness in	Weight of a Sq. Ft.	Weight per Ft. Sq. Bar.	Weight per Ft. Rd. Bar.
Inches.	Pounds.	Pounds.	Pounds.	Inches.	Pounds.	Pounds.	Pounds.
1/32	1.263	.0033	.0026	15/16	37.89	2.960	2.325
1/16	2.526	.0132	.0104	1	40.42	3.368	2.645
3/32	3.789	.0296	.0233	1/16	42.94	3.803	2.986
1/8	5.052	.0526	.0414	1/8	45.47	4.263	3.348
5/32	6.315	.0823	.0646	3/16	48.00	4.750	3.730
3/16	7.578	.1184	.0930	1/4	50.52	5.263	4.133
7/32	8.841	.1612	.1266	5/16	53.05	5.802	4.557
1/4	10.10	.2105	.1653	3/8	55.57	6.368	5.001
9/32	11.37	.2665	.2093	7/16	58.10	6.960	5.466
5/16	12.63	.3290	.2583	1/2	60.63	7.578	5.952
11/32	13.89	.3980	.3126	5/8	65.68	8.893	6.985
3/8	15.16	.4736	.3720	3/4	70.73	10.31	8.101
13/32	16.42	.5558	.4365	7/8	75.78	11.84	9.300
7/16	17.68	.6446	.5063	2	80.83	13.47	10.58
15/32	18.95	.7400	.5813	1/8	85.89	15.21	11.95
1/2	20.21	.8420	.6613	1/4	90.94	17.05	13.39
9/16	22.73	1.066	.8370	3/8	95.99	19.00	14.92
5/8	25.26	1.316	1.033	1/2	101.0	21.05	16.53
11/16	27.79	1.592	1.250	5/8	106.1	23.21	18.23
3/4	30.31	1.895	1.488	3/4	111.2	25.47	20.01
13/16	32.84	2.223	1.746	7/8	116.2	27.84	21.87
7/8	35.37	2.579	2.025	3	121.3	30.31	23.81

Flat bars may be estimated by dividing the size by a square number; as, one-quarter inch by one inch. One-fourth that of one inch square.

TO TEST QUALITY OF IRON.—If fracture gives long silky fibres of leaden-grey hue, fibres cohering and twisting together before breaking, may be considered a *tough*, *soft iron*. A medium, even grain mixed with fibres a good sign. A short, blackish fibre indicates badly refined iron. A very fine grain denotes a ***hard***, *steely iron*, apt to be cold-short, hard to work with the file. Coarse grain with brilliant crystallized fracture, yellow or brown spots, denotes a *brittle iron*, cold-short, working easily when heated; welds easily. Cracks the edge of bars, sign of hot, short iron. Good iron is readily heated soft, under the hammer, and throws out but few sparks.

All iron contains more or less carbon—the hardest the most.

NOTE ON FORGINGS.—Iron, while heating, if exposed to air, will *oxidize;* while at white heat, if in contact with coal, will carbonize, or become steely. Iron should be heated as rapidly as possible.

SIMPLE METHOD OF TESTING THE QUALITY OF STEEL.—Good steel, in its soft state, has a curved fracture and uniform gray luster; in its hard state, a dull, silvery, uniform white. Cracks, threads, or sparkling particles denote bad quality.

Good steel will not bear a white heat without falling to pieces, and will crumble under the hammer at a bright, red heat, while at a middling heat it may be drawn out under the hammer to a fine point. Care should be taken that before attempting to draw it out to a point, the fracture is not concave, and should it be so, the end should be filed to an obtuse point before operating. Steel should be drawn out to a fine point and plunged into cold water; the fractured point should scratch glass.

To test its toughness, place a fragment on a block of cast-iron; if good, it may be driven by the blow of a hammer into the cast-iron; if poor, it will crush under the blow.

Nitric acid will produce a black spot on steel; the darker the spot the harder the steel. Iron, on the contrary, remains bright if touched with nitric acid.

TEMPERING STEEL.

Color.	Purpose.	Tem.	Alloy whose fusing point is same temperature.
		Fah.	Tin Lead.
Light straw	Turning tools for metal.	430°	1 to 1¾
Dark straw	Wood tools, taps & dies.	470°	1 to 2½
Brown yellow	Hatchets, Chip'g chis.	500°	1 to 4¾
Dark purple	Springs, etc.	550°	1 to 12

HORSE-POWER OF BOILERS.—With good natural draft, flue boilers should have about 10 square feet of heating surface for the evaporation of 1 cubic foot of water per hour; and this evaporation per hour may be taken to represent 1 horse-power.

The coal required to effect this evaporation will generally be about 8 pounds, and the grate surface provided for the combustion of this amount of coal per hour should be about half a square foot. Therefore, for each horse-power that a flue boiler is expected to develop economically, the following will be required:

10 square feet of heating surface.
½ square foot of grate surface.
1 cubic foot of water per hour.
8 lbs. of good coal per hour.

Tubular boilers should have 13 square feet of heating surface for each horse-power.

Boilers may be made to do more than double this amount of work by the use of a forced draft, but at a great waste of fuel, and increased danger, which should be avoided as far as possible.

The strength of cylinder boilers is directly as their thickness, and inversely as their diameter. That is, if one of two boilers which have the same diameter is twice as thick as the other, it is twice as strong. And if one of two boilers, made of the same thickness, is twice the diameter of the other, it is only half as strong.

TABLE GIVING HORSE-POWER OF BOILERS THE FOLLOWING SIZES.

Diameter Shell. Inches.	Length Shell. Feet.	Number Tubes.	Length Tubes. Feet.	Diameter Tubes. Inches.	Heating Surface. Square ft.	Horse-Power 60 lbs. Pressure.
72	18	70	18	4	1502	100
72	16	90	16	3½	1472	98
72	16	112	16	3	1496	99
72	15	112	15	3	1400	93
60	18	65	18	3½	1200	80
60	17	65	17	3½	1148	76
60	16	65	16	3½	1075	72
60	16	80	16	3	1088	72
60	15	80	15	3	1020	68
60	14	80	14	3	952	63
60	13	80	13	3	884	59
54	18	50	18	3½	951	63
54	17	50	17	3½	900	60
54	16	50	16	3½	795	53
54	16	60	16	3	832	55
54	15	60	15	3	780	52
54	14	60	14	3	728	48
54	13	60	13	3	676	45
54	12	60	12	3	624	41
48	16	40	16	3½	683	46
48	16	49	16	3	684	46
48	15	49	15	3	642	43
48	14	49	14	3	600	40
48	13	49	13	3	555	37
48	12	49	12	3	513	34
48	11	65	11	2½	542	36
48	10	65	10	2½	495	33
42	15	38	15	3	508	34
42	14	38	14	3	476	32
42	13	38	13	3	441	30
42	12	38	12	3	408	27
42	11	45	11	2½	390	26
42	10	45	10	2½	355	24
42	9	45	9	2½	320	22
42	8	45	8	2½	285	19
42	7	45	7	2½	248	16

COMPARATIVE VALUE OF DIFFERENT KINDS OF WOOD FOR FUEL.

The following table shows the weight of one cord of various kinds of wood, dry, and their relative values for fuel, red oak being taken as the standard:

KIND OF WOOD.	Weight of one Cord in pounds.	Relative value for Fuel.
Red Oak,	3,254	1.00
Shell-bark Hickory,	4,469	1.45
Chestnut White Oak,	3,955	1.25
White Oak,	3,821	1.17
White Ash,	3,450	1.12
White Beech,	3,236	.94
Black Walnut,	3,044	.94
Black Birch,	3,115	.91
Yellow Oak,	2,919	.37
Hard Maple,	2,878	87
White Elm,	2,592	.84
Large Magnolia,	2,704	.81
Soft Maple,	2,668	.78
Soft Yellow Pine,	2,463	.78
Sycamore,	2,391	.75
Chestnut,	2,333	.75
White Birch,	2,369	.70
Jersey Pine,	2,137	.70
Pitch Pine,	1,904	.62
White Pine,	1,868	.61

NOTES ON PACKING.—In packing rods use only the best packing, consisting of rubber elastic packing, soapstone, asbestos. Hemp or lamp-wick well tallowed makes a good packing. Many practice the plan of cutting up strips of old rubber belting for packing. Such stuff will ruin machinery. The rubber consists of substitutes that stand no heat and crumble or parch, heating and cutting the rod. Remove all old packing from stuffing boxes and do not set up new packing too tight.

Joints should be packed either with wire gauge, packing gum, sheet copper or a lead joint. The latter is necessary in connecting boilers and engine together where a close, flat fit cannot always be had. In such cases it is best to cut a ring from a piece of rubber belting exact size of pipe inside, about one-half wide; place this ring in the centre of joint, measuring equally from edge of flange, then tighten sufficiently to be certain that it forms an air-tight joint; then plaster outside of flanges with stiff clay, or tie a strap tightly around, leaving a hole for pouring metal; then plaster the outside and a neat joint will be run. Pour lead and tighten bolts as steam rises and you have a joint that can be relied upon. Steam drums that are bolted instead of riveted must have such joints.

Joints that must be broken often should be of sheet copper, which can be broken as often as desired and will maintain a good joint.

Man-heads to boilers often give much trouble, owing to irregularities. By using a lead ring, a good joint is had and may be broken as often as desired, but should be well tallowed. Hemp plaited, well white-leaded, will answer for a short while, but must be replaced when broken if very old.

FILES AND THEIR USE.—To choose a flat file, turn its edge upward and look along it, selecting one which has an even sweep from end to end, and having no flat places or hollows. To choose a half-round file, turn the edge upward, look along it and select that which has an even sweep and no flat or hollow places on the half-round side, even though it be hollow in the length of the flat side.

In draw-filing, take short, quick strokes, which will prevent the file from pinning and scratching. Long strokes, no matter how long the work may be, are useless save to make scratches. Remember it is less the number of strokes given the file than the weight placed upon it that is effective; therefore, when using a rough file, stand sufficiently away from the work to bring the weight of the body upon the forward stroke. New files should be used at first upon broad surfaces, since narrow edges are apt to break the teeth if they have the fibrous edges unworn.

For brass work use the file on a broad surface until its teeth are dulled, then make two or three strokes of the file under a heavy pressure upon the edge of a piece of sheet iron, which will break off the dulled edges of the teeth, and leave a new fibrous edge for brass work.

Use bastard-cut files to take off a quantity of metal of ordinary hardness; second-cut in fitting, and also to file unusually hard metal; smoothing to finish in final adjustment or preparatory to applying emery cloth; dead smooth, to finish very fine work; float file on lathe work.

To prevent files from pinning, and hence from scratching, properly clean them, and then chalk them well.

To Test Hard and Soft Water.—Dissolve a little good soap in alcohol and let a few drops fall into a glass of water. If the water is hard it will turn milky; if soft, it will not.

Ingenious Way of Cooling a Journal.—Quite an ingenious way of cooling a journal that cannot be stopped is to hang a short endless belt on the shaft next to the box and let the lower part of it run in cold water. The turning of the shaft carries the belt slowly around, bringing fresh cold water continually in contact with the heated shaft, and without spilling or spattering a drop of water.

Cement for Iron that will resist Hammer Blows.—The following mixture has been used with the greatest possible success for the cementing of iron railing tops, iron gratings to stoves, etc., in fact, with such effect as to resist the blows of a sledge hammer.

This mixture is composed of equal parts of sulphur and whitelead, with about one-sixth proportion of borax, the three being thoroughly incorporated together, so as to form one homogeneous mass. When the application is to be made of this composition, it is wet with strong sulphuric acid, and a thin layer of it is placed between the two pieces of iron, these being at once pressed together. In five days it will be perfectly dry, all traces of the cement having vanished, and the work having every appearance of welding.

To Make a Cheap Telephone.—To make a serviceable telephone from one house to another only requires enough wire and two cigar boxes. First, select your boxes, and make a hole half an inch in diameter in the centre of the bottom of each, and then place one in each of the houses you wish to connect; then get five pounds of common iron stove-pipe wire, make a loop in one end and put it through the hole in your cigar box and fasten it with a nail; then draw it tight to the other box, supporting it when necessary with a stout cord.

You can easily run your line into the house by boring a hole through the glass. Support your boxes with slats nailed across the window and your telephone is complete. The writer has one that is two hundred yards long, and cost forty-five cents, that will carry music when the organ is playing thirty feet away in another room.

TABLE

Showing the number of days from a given day in any month to the same day in any other month.

FROM / TO	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
January	365	31	59	90	120	151	181	212	243	273	304	334
February	334	365	28	59	89	120	150	181	212	242	273	303
March	306	337	365	31	61	92	122	153	184	214	245	275
April	275	306	334	365	30	61	91	122	153	183	214	244
May	245	276	304	335	365	31	61	92	123	153	185	214
June	214	245	273	304	334	365	30	61	92	122	153	183
July	184	215	243	274	304	335	365	31	62	92	123	153
August	153	184	212	243	273	304	334	365	31	61	92	122
September	122	153	181	212	242	273	303	334	365	30	61	91
October	92	123	151	182	212	243	273	304	335	365	31	61
November	61	92	120	151	181	212	242	273	304	334	365	30
December	31	62	90	121	151	182	212	243	274	304	335	365

EXAMPLE.

To find the number of days from June 16th to October 16th:—

In the left-hand column find June. Run your eye along to the right until it reaches the column headed October at the top. At the intersection of the two columns you will find the answer, 122 days.

SHORT METHOD OF CALCULATING INTEREST.—RULE —Multiply the principal by the number of days and divide by 6. Point off three figures, and you have the interest at 6 per cent. in dollars, cents and mills. Then to obtain the interest at any other per cent., divide the result obtained at 6 per cent. by 6, which will give the interest at 1 per cent. Multiply the interest at 1 per cent. by the rate desired, and you have the answer.

EXAMPLE.

Find the interest of $216 for 124 days, at 5 per cent.

```
       $216
        124
       ----
        864
       432
      216
     ------
  6) 26784
     ------
  6) $4.464 Interest on $216 for 124 days at 6 per cent.
     ------
       .744 Interest on $216 for 124 days at 1 per cent.
          5
     ------
     $3.720 Interest on $216 for 124 days at 5 per cent.
```

When fractions occur in dividing it is usual to ignore them, as the result in such cases, while not absolutely accurate to the fraction of a mill, is near enough for all practical purposes.

The person who masters this simple rule thoroughly has no occasion to resort to interest tables for the calculation of interest.

PRACTICAL RECEIPTS FOR MACHINISTS AND MILLMEN.

ANTI-FRICTION METAL.—Copper, 4 lbs.; regulus of antimony, 8 lbs., Banca tin, 96 lbs. 2 Grain zinc, 7½ lbs.; purified zinc, 7¼ lbs.; antimony, 1 lb. 3. Zinc, 17 parts; copper, 1 part; antimony, 1½ parts. This possesses unsurpassable anti-friction qualities, and does not require the protection of outer castings of a harder metal. 4. Block tin, 8 lbs.; antimony, 2 lbs.; copper, 1 lb. If the metal be too hard, it may be softened by adding some lead. 5. The best alloy for journal boxes is composed of copper, 24 lbs.; tin, 24 lbs., and antimony, 8 lbs. Melt the copper first, then add the tin, and lastly the antimony. It should be first run into ingots, then melted, and cast in the form required for the boxes. 6. Melt in a crucible 1½ lbs. of copper, and, while the copper is melting, melt in a ladle 25 lbs. of tin and 3 of antimony, nearly red hot, pour the two together, and stir until nearly cool. This makes the finest kind of lining metal. 7. *Very cheap*. Lead 100 lbs.; antimony, 15 lbs. This costs about 10 cents per lb. 8. *For Bearings to sustain great weights.*—Copper, 1 lb.; zinc, ½ oz.; tin, 2½ oz. 9. *Hard bearings for machinery.*—Copper, 1 lb.; tin, 2 ozs. 10. *Very Hard ditto.*—Copper, 1 lb.; tin, 2½ ozs. 11. *Lining Metal for boxes of Railway Cars.*—Mix tin, 24 lbs.; copper 4 lbs.; antimony, 8 lbs.; (for a hardening) then add tin 72 lbs. 12. *Lining Metal of Locomotives' Axle trees.*—Copper, 86.03.; tin, 13.97. 13. *Another, French.*—Copper, 82 parts; tin, 10 parts; zinc, 8 parts. 14. *Another, (Stephenson's).*—Copper, 79 parts; tin, 8 parts; zinc, 5 parts; lead, 8 parts. 15. *Another (Belgian).*—Copper, 89.02, parts; tin, 2.44 parts; zinc, 7.76 parts; iron, 0.78. 16. *Another (English).*—Copper, 73.96 parts; tin, 9.49 parts; zinc, 9.03 parts; lead, 7.09 parts; iron, 0.43 parts. 17. *Another.*—Copper, 90.06 parts; tin, 3.56 parts; zinc, 6.38. of *Nickel Anti-friction Metal.*—A late improvement in the manufacture of anti-friction metal is the introduction of a small percentage of nickel into either of the above, or any other anti-friction composition.

BRAZING CAST-IRON.—There are two ways of joining cast-iron. 1. Fit the broken pieces exactly together in moulding sand and pour melted iron over the parts to be joined. When cold, chip off the superfluous metal and you will have a joint scarcely to be detected. 2.

Well tin the parts to be joined, fit together in sand as above, and pour melted brass over them.

TO BEND GLASS TUBES.—Hold the tube in the upper part of the flame of a spirit-lamp, revolving it slowly between the fingers; when red hot it may be easily bent into any desired shape. To soften large tubes a lamp with a double current of air should be used, as it gives a much stronger heat than the simple lamp.

TEMPERING POINTS OF TOOLS.—After being tempered the volume of the tool is slightly increased, and consequently its specific gravity is decreased. As the expansion, or increase, of volume is so very slight, it is quite immaterial which is plunged into the liquid first; however, every moment the edge is kept out it is cooling, and the tempering may be rendered defective thereby. Mercury tempers the hardest, then water, then salt water, then oil of various kinds—as whale oil. As oil cools the metal more slowly, it is not tempered so hard but the tenacity is increased.

THE UNITED STATES GOVERNMENT TEMPERING SECRET.—The following process and mixtures, patented by Garman and Siegfried, and owned by the Steel Refining and Tempering Co., of Boston, Mass., cost the U. S. Government $10,000 for the right of using in their shops, and is said to impart extraordinary hardness and durability to the poorest kinds of steel. Seigfried's specification reads as follows: "I first heat the steel to a cherry red in a clean smith's fire, and then cover the steel with chloride of sodium (common salt), purifying the fire also by throwing in salt. I work the steel in this condition, and while subjected to this treatment, until it is brought into nearly its finished form. I then substitute for the salt a compound composed of the following ingredients, and in about the following proportions: One part by weight of each of the following substances: chloride of sodium (salt), sulphate of copper, sal-ammoniac, and sal-soda, together with ½ part by weight of pure nitrate of potassa (salt-petre), said ingredients being pulverized and mixed; I alternately heat the steel and treat it by covering with this mixture and hammering it until it is thoroughly refined and brought into its finished form. I then return it to the fire and heat it slowly to a cherry red, and then plunge it into a bath composed of the following ingredients, in substantially the following proportions for the required quantity: Of rain water, 1 gal.; alum, sal-soda, sulphate of copper, of each 1½ ozs.; of nitrate of potassa (salt-petre), 1 oz., and of chloride of sodium (salt), 6 ozs. These quantities and proportions are stated as being what I regard as practically the best, but it is manifest that they may be slightly changed without departing from the principles of my invention."

CEMENT TO MEND LEAKY BOILERS.—Powdered litharge, 2 parts; very fine sand, 2 parts; slaked quick lime, 1 part. Mix all together. To use, mix the proper quantity with boiled linseed oil and apply quick. It gets hard very soon.

STRONG CEMENT FOR STEAM JOINTS.—Whitelead ground in oil, 10 parts; black oxide of manganese, 3 parts; litharge, 1 part. Reduce to the proper consistency with boiled linseed oil and apply.

CEMENT FOR HOLES OR CRACKS.—Redlead ground in oil, 6 parts; whitelead, 3 parts; oxide of manganese, 2 parts; silicate of soda, 1 part; litharge, ½ part, all mixed and used as putty.

RUST JOINT, QUICK SETTING.—Sal ammoniac pulverized, 1 lb.; flour of sulphur, 2 lbs.; iron borings, 80 lbs.; mix to a paste with water in quantities as required for immediate use.

QUICK SETTING JOINS BETTER THAN THE LAST, BUT REQUIRES MORE TIME TO SET.—Sal ammonia, 2 lbs.; sulphur, 1 lb.; iron filings, 206 lbs.

Air and Water-tight Cement for Casks and Cisterns.—Melted glue, 8 parts; linseed oil, 4 parts; boiled into a varnish with litharge; hardens in 48 hours.

Marine Glue.—India rubber, 1 part; coal tar, 12 parts; heat gently, mix, and add 20 parts of powdered shellac, pour out to cool; when used, heat to about 250°.

Another Ditto.—Glue, 12 parts; water, sufficient to dissolve, add yellow resin, 3 parts, melt, then add turpentine, 4 parts; mix thoroughly together.

Cement for External Use.—Ashes, 2 parts; clay, 3 parts; sand, 1 part; mix with a little oil, very durable.

Cement to Resist Red Heat and Boiling Water.—To 4 or 5 parts of clay, thoroughly dried and pulverized, add 2 parts of fine iron filings free from oxide, 1 part of peroxyde of manganese, 1 part of common salt, and ½ part of borax. Mingle thoroughly, render as fine as possible, then reduce to thick paste with the necessary quantity of water, mixing well, use immediately, and apply heat, gradually increasing almost to a white heat.

Cement to Join Sections of Cast-Iron Wheels, etc.—Make a paste of pure oxide of lead, litharge and concentrated glycerine. Unrivalled for fastening stone to stone or iron to iron.

Varnish for Boilers.—Asphaltum dissolved in turpentine.

Soft Cement for Steam-boilers, Steam-pipes, etc.—Red or whitelead, in oil, 4 parts; iron borings 2 to 3 parts.

Hard Cement.—Iron borings in salt water and a small quantity of sal ammoniac with fresh water.

Gasfitters' Cement.—Mix together resin, 4¼ parts, wax, 1 part, and venetian red, 3 parts.

Plumbers' Cement.—Black resin, 1 part; brick dust, 2 parts; well incorporated by a melting heat.

COPPERSMITHS' CEMENT.—Boiled linseed oil and redlead mixed together into a putty, are often used by coppersmiths and engineers to secure joints; the washers of leather or cloth are smeared with this mixture in a pasty state.

COMPOSITIONS TO FILL HOLES IN CASTINGS.—Mix 1 part of borax in solution with 4 parts dry clay. *Another*.—Pulverized binoxide of manganese, mixed with a strong solution of silicate of soda (water clay) to form a thick paste.

CAST-IRON CEMENT.—Clean borings or turnings of cast-iron, 16 parts; sal ammoniac, 2 parts; flour of sulphur, 1 part; mix them well together in a mortar, and keep them dry. When required for use, take of the mixture, 1 part; clean borings, 20 parts; mix thoroughly, and add a sufficient quantity of water. A little grindstone dust added improves the cement.

CEMENT FOR STEAM-PIPE JOINTS, ETC., WITH FACED FLANGES.—Whitelead, mixed, 2 parts; redlead, dry, 1 part; grind, or otherwise mix them to a consistence of thin putty; apply interposed layers with 1 or 2 thicknesses of canvas or gauze wire, as the necessity of the case may be.

CEMENT FOR JOINTS OF IRON PIPES OR HOLES IN CASTINGS.—Take of iron borings, coarsely powdered, 5 lbs.; of powdered sal ammoniac, 2 oz.; of sulphur, 1 oz., and water sufficient to moisten it. This composition hardens rapidly, but, if time can be allowed, it sets more firmly without the sulphur. Use as soon as mixed, and ram tightly into the joints or holes.

BEST CEMENT FOR AQUARIA.—One part, by measure, say a gill, of litharge; 1 gill of plaster of Paris; 1 gill of dry, white sand; $\frac{1}{3}$ a gill of finely powdered resin. Sift and keep corked tight until required for use, when it is to be made into a putty by mixing in boiled oil (linseed) with a little patent drier added. Never use it after it has been mixed (that is, with the oil) over fifteen hours. This cement can be used for marine as well as fresh water aquaria, as it resists the action of salt water. The tank can be used immediately, but it is best to give it three or four hours to dry.

ANOTHER.—Mix equal quantities of any whitelead and redlead to a paste with mastic varnish and use as soon as mixed.

CEMENT FOR BELTING.—*Waterproof*—Dissolve gutta percha in bisulphide of carbon to the consistence of molasses, slice down and thin the ends to be united, warm the parts and apply the cement, then hammer lightly on a smooth anvil, or submit the parts to heavy pressure.

TO REPAIR LEAKAGES IN FIRE ENGINE HOSE.—Pass a round bar of iron into the hose under the leak, then rivet on a patch of leather, previously coated with marine glue.

TO REPAIR RUBBER HOSE.—Cut the hose apart where it is defective; obtain from any gasfitter a piece of iron pipe 2 or 3 inches long, twist the hose over it until the ends meet, wrap with strong twine, well waxed, and it will last a long time.

PORTABLE GLUE FOR DRAUGHTSMEN.—Glue, 5 ozs.; sugar, 2 ozs.; water, 8 ozs.; melt in a water bath, cast it in molds. For use, dissolve in warm water.

CEMENTING EMERY TO WOOD.—Melt together equal parts of shellac, white resin and carbolic acid in crystals; add the last after the others are melted.

TO COAT IRON WITH EMERY.—Give the iron a good coat of oil and whitelead; when this gets hard and dry, apply a mixture of glue and emery.

TO CLEAN COTTON WASTE.—Pack the waste in a tin cylinder with a perforated false bottom and tube with stop-cock at bottom. Pour on the waste bisulphide of carbon sufficient to cover, and allow to soak a few minutes; then add more bisulphide, and so on for a time or two, and then squeeze out. By simple distillation the whole of the bisulphide, or nearly all, can easily be recovered and so be used over again. This will free the cotton completely from grease.

French Putty.—Seven pounds linseed oil and 4 lbs. brown umber are boiled for two hours, and 62 grammes wax stirred in. After removal from the fire 5½ lbs. fine chalk and 11 lbs. whitelead are added and thoroughly incorporated; said to be very hard and permanent.

To Mend Cracked Cast-Iron Vessels.—Drill a hole at each extreme end of the crack, to prevent its further extension, plug rivet the holes with copper, and, with fine iron filings saturated with urine, caulk the crack. Four parts of pulverized clay and one part of iron filings made into a paste with boiling linseed oil and applied hot is a good cement for the same purpose.

To Prevent Iron Rusting.—Give it a coat of linseed oil and whiting, mixed together in the form of a paste. It is easily removed and will preserve iron from rusting for years.

Glue for Labelling on Metals. — Boiling water, 1 qt.; pulverized borax, 2 ozs.; gum shellac, 4 ozs. Boil till dissolved. Used for attaching labels to metals, or it will do to write inscriptions with, and dust or dab on a little bronze powder over it, varnishing over the bronze.

Cement for Petroleum Lamps.—Boil 3 parts of resin with 1 part of caustic soda and 5 of water. The composition is then mixed with half its weight of plaster of Paris, and sets firmly in ½ to ¾ of an hour. It is of great adhesive power, not permeable to petroleum, a low conductor of heat, and but superficially attacked by hot water.

For Lute, or cement for closing joints of apparatus, mix Paris plaster with water to a soft paste, and apply it at once. It bears nearly a red heat. To render it impervious, rub it over with wax and oil.

ROMAN CEMENT.—Slaked lime, 1 bush.; green copperas, 3½ lbs.; fine gravel sand, ½ bush. Dissolve the copperas in hot water, and mix all together to the proper consistency for use; use the day it is mixed and keep stirring it with a stick while in use.

VICAT'S HYDRAULIC CEMENT is prepared by stirring into water a mixture of 4 parts chalk and 1 part clay; mix with a vertical wheel in a circular trough, letting it run out in a large receiver. A deposit soon takes place which is formed into small bricks, which after being dried in the sun, are moderately calcined. It enlarges about $\frac{2}{8}$ when mixed with water.

GLUE TO RESIST MOISTURE.—Glue, 5 parts; resin, 4 parts; red ochre, 2 parts; mix with the smallest possible quantity of water.

CEMENT TO FASTEN LEATHER ON TOP ROLLERS. —Gum Arabic, 2¾ ozs.; isinglass 2¾ ozs.; dissolve each separately in water and mix.

PARCHMENT GLUE.—Parchment shavings, 1 lb; water, 6 qts. Boil till dissolved, strain and evaporate to right consistence.

TO ATTACH GLASS OR METAL LETTERS TO PLATE GLASS.—Copal varnish, 15 parts; drying oil, 5 parts; turpentine, 3 parts; oil of turpentine, 2 parts; liquefied glue, 5 parts. Melt in a water bath and add 10 parts of slaked lime.

TURNERS' CEMENT.—Beeswax, 1 oz.; resin, ½ oz.; pitch, ½ oz.; melt, and stir in fine brickdust.

BANK NOTE GLUE.—Dissolve 1 lb. of fine glue or gelatine in water; evaporate it till most of the water is expelled; add ½ lb. of brown sugar, and pour it into moulds.

CEMENT FOR ELECTRICAL MACHINES AND GALVANIC TROUGHS.—Melt together 5 lbs. of resin and 1 lb. of beeswax, and stir in 1 lb. of red ochre (highly dried and still warm) and 4 oz. of plaster of Paris, continuing the heat a little above 212°, and stirring constantly till all frothing ceases, or (for troughs) rosin, 6 lbs.; dried red ochre, 1 lb.; calcined plaster of Paris, ½ lb.; linseed oil, ¼ lb.

ARCHITECTURAL CEMENT—1. Reduce paper to a smooth paste by boiling it in water; then add an equal weight of sifted whiting and good size; boil to a proper consistence. 2. Paper paste and size, equal parts; finely powdered plaster of Paris to make it of a proper consistence. Use it as soon as mixed. Can be used in making architectural busts, statues, columns, etc. It is light, receives a good polish, but will not stand water.

ALABASTER CEMENT—1. Finely powdered plaster of Paris, made into a paste with water. 2. Melt yellow rosin, or equal parts yellow rosin and beeswax, then stir in half as much finely powdered plaster of Paris. The first is used to join and fit together pieces of alabaster or marble, or to mend broken plaster figures. The second is to join alabaster, marble, and other similar substances that will bear being heated.

FRENCH CEMENT FOR ROOMS.—A coat of oxide of zinc, mixed with size, made up like a wash, is first laid on the wall, ceiling, or wainscot, and over that a coat of chloride of zinc applied, prepared in the same way as the first wash. The oxide and chloride effect an immediate combination, and form a kind of cement, smooth and polished as glass, and said to be superior to plaster of Paris for coating the walls of rooms.

CEMENT FOR CLOTH OR LEATHER.—Take ale, 1 pt.; best Russia isinglass, 2 ozs.; put them into a common glue kettle and boil until the isinglass is dissolved; then add 4 ozs. of the best common glue, and dissolve it with the other; then slowly add 1½ ozs. of boiled linseed oil, stirring all the time while adding, and until well mixed. When cold it appears like India rubber. To use, dissolve what you need in a suitable quantity of ale to have the consistence of thick glue. It is applicable for earthenware, china, glass, or leather; for harness, belts for machinery, cloth belts for cracker machines for bakers, etc. If for leather, shave off as if for sewing, apply the cement with a brush while hot, laying a weight to keep the joint firmly pressed for 6 to 10 hours, or over night.

CUTLERS' CEMENT.—Black rosin, 4 lbs.; beeswax, 1 lb.; melt together and add 1 lb. finely powdered and dried brickdust. Used for fastening knives and forks in their handles when they become loosened by use.

CEMENT FOR FASTENING FIBROUS MATERIALS TO METALS.—This can be effected by dissolving glue in vinegar by heat and adding one-third of its volume of white pine pitch, also hot.

GOOD PASTE THAT WILL KEEP A YEAR.—Dissolve a teaspoonful of alum in a quart of warm water. When cold, stir in as much flour as will bring it to the consistence of cream, being particular to break up all the lumps; next, place it on the fire and allow it to cook gently for a few minutes, stirring well meanwhile; add 2 teaspoonfuls of corrosive sublimate, a few drops of carbolic acid, and a teaspoonful of oil of rosemary, or cloves, or lavender, or any other essential oil, stirring in well. This paste will keep for any length of time in prime condition.

MUCILAGE.—Put 3 ozs. of gum arabic in an earthen-ware vessel containing ½ pt. of cold water. If the liquid is occasionally stirred, the gum in 24 hours will be dissolved and ready for use.

CEMENT TO FASTEN RUBBER TO WOOD OR METAL.—Soak pulverized gum shellac in 10 times its weight of ammonia; in 3 or 4 weeks a slimy mass is obtained which will become liquid without the use of hot water; this softens the rubber, and becomes, after volatilization of the ammonia, hard and impermeable to gases and fluids whenever it is used on rubber connected to wood or metal, as in steam, or other apparatus.

IMPERISHABLE PUTTY.—Linseed oil, 7 lbs.; brown umber, 4 lbs.; boil together two hours; stir in 2 oz. beeswax, remove from the fire, and mix in 5½ lbs. chalk and 11 lbs. white lead, mixing thoroughly.

CHEAP GOLD VARNISH FOR ORNAMENTAL TIN-WARE.—Turpentine varnish, 2 gals.; turpentine, 1 gal.; asphaltum, 1 gill; umber, 8 oz.; yellow aniline, 4 oz.; gamboge, 1 lb. Boil and mix for 10 hours.

SOLDERS, 32 KINDS.—1. *Plumbers' Solder.*—Lead, 2 parts; tin, 1 part. 2. *Tinmen's Solder.*—Lead, 1 part; tin, 1 part. *Zinc Solder.*—Tin, 1 part; lead, 1 to 2 parts. 4. *Pewter Solder.*—Lead, 1 part; bismuth, 1 to 2 parts. 5. *Spelter Solder.*—Equal parts copper and zinc. 6. *Pewterers' soft Solder.*—Bismuth, 2; lead, 4; tin, 3 parts. 7. *Another.*—Bismuth, 1; lead, 1; tin, 2 parts. 8. *Another pewter Solder.*—Tin, 2 parts; lead, 1 part. 9.—*Glazier's Solder.*—Tin, 3 parts; lead, 1 part. 10. *Solder for Copper.*—Copper, 10 parts; zinc, 9 parts. 11. *Yellow Solder for Brass or Copper.*—Copper, 32 lbs.; zinc, 29 lbs.; tin, 1 lb. 12. *Brass Solder.*—Copper, 61.25 parts; zinc, 38.75 parts. 13. *Brass Solder Yellow and easily fusible.*—Copper 45; zinc, 55 parts. 14. *Brass Solder, white.*—Copper, 57.41 parts; tin, 14.60 parts; zinc, 27.99 parts. 15. *Another Solder for Copper.*—Tin, 2 parts; lead, 1 part. When the copper is thick, heat it by a naked fire; if thin, use a tinned copper tool. Use muriate or chloride of zinc, as a flux. The same solder will be for *iron, cast-iron* or *steel;* if the pieces are thick, heat by a naked fire, or immerse in the solder. 16. *Black Solder.*—Copper, 2; zinc, 3; tin, 2 parts. 17. *Another.*—Sheet brass, 20 lbs.; tin, 6 lbs.; zinc, 1 lb. 18. *Cold Brazing without Fire or Lamp.*—Fluoric acid, 1 oz.; oxy muriatic acid, 1 oz.; mix in a lead bottle. Put a chalk mark each side where you want to braze. This mixture will keep about six months in one bottle. 19. *Cold Soldering without Fire or Lamp.*—Bismuth, ¼ oz.; quick-silver, ¼ oz.; block tin filings, 1 oz.; spirits salts, 1 oz.; all mixed together. 20. *To Solder Iron to Steel or either to Brass.*—Tin, 3 parts; copper, 39½ parts; zinc, 7½ parts. When applied in a molten state it will firmly unite metals first named to each other. 21. *Plumbers' Solder.*—Bismuth, 1; lead, 5; tin, 3 parts; is a first class composition. 22. *White Solder for raised Britannia Ware.*—Tin, 100 lbs.; hardening, 8 lbs.; antimony, 8 lbs. 23. *Hardening for Britannia.*—(To be mixed separately from the other ingredients). Copper, 2 lbs,; tin, 1 lb. 24. *Best soft Solder for cast Britannia Ware.*—Tin, 8 lbs.; lead, 5 lbs. 25. *Bismuth Solder.*—Tin, 1; lead, 3; bismuth, 3 parts. 26. *Solder for Brass that will Stand Hammering.*—Brass, 78.26 parts; zinc, 17.41 parts; silver, 4.33 parts; add a little chloride of potassium to your borax for a flux. 27. *Solder for Steel Joints.*—Silver, 19 parts; copper, 1 part; brass, 2 parts. Melt all together. 28. *Hard Solder.* Copper, 3 parts; zinc, 1 part. Melt together. 29. *Solder for Brass.*—Copper, 3 parts; zinc, 1 part; with borax. 30. *Solder for Copper.*—Brass, 6 parts; zinc, 1 part; tin, 1 part; melt all together well, and pour out to cool. 31. *Solder for Platina.*—Gold with borax. 32. *Solder for Iron.*—The best solder for iron is good tough brass with a little borax.

N. B. In soldering, the surfaces to be joined are made perfectly clean and smooth, and then covered with sal ammoniac, resin or other flux, the solder is then applied, being melted on and smoothed over by a tinned soldering iron.

SOLDERING FLUID.—Take 2 oz. muriatic acid; add zinc till bubbles cease to rise; add ½ teaspoonful of sal ammoniac.

BLACK VARNISH FOR COAL BUCKETS.—Asphaltum, 1 lb.; lampblack, ¼ lb.; resin, ½ lb.; spirits of turpentine, 1 qt. Dissolve the asphaltum and resin in the turpentine, then rub up the lampblack with linseed oil, only sufficient to form a paste, and mix with the others. Apply with a brush.

SIZES OF TIN-WARE OF DIFFERENT KINDS.

(*For Diameters, &c., of Circles see Tables.*)

		Diam. of bot.	Diam. of top.	Heig't
		inches.	inches.	inches
DIPPERS	½ gal.	4	6½	4
"	1 pt.	3¾	4¼	2¾
COFFEE POTS	1 gal.	7	4	8½
" "	3 qts.	6	3½	8½
PANS	20 qts.	13	19½	8
"	16 qts.	11¼	18	6¼
"	14 qts.	9¼	15¼	6¼
"	10 qts.	11	14¾	4⅛
"	6 qts.	9	12¾	4
"	2 qts.	6	9	3¾
"	3 pts.	5	8¼	2¾
"	1 pt.	4¾	6¼	2¾
PIE PANS		7	9	1¾
LARGE WASH BOWL		5½	11	5
SMALL WASH BOWL		5¾	9½	5
MILK STRAINER		5½	9½	3½
PAILS AND DISH KETTLES	14 qts.	9½	13	9
" " " "	10 qts.	7	11½	9
" " " "	6 qts.	5	9¼	6½
" " " "	2 qts.	4½	6¼	4
COLANDER		5	11	5
MEASURES for Druggists, Beer, etc.	2 gal.	6¾	10½	8⅜
	1 gal.	8	3¾	7½
	½ gal.	6¾	3⅛	6
	1 qt.	5⅝	2½	4⅞
	1 pt.	4⅛	2	4
	½ pt.	3	1¾	3⅛
MEASURES of other forms	1 gal.	6¾	5½	9¼
	½ gal.	4⅛	4	8
	1 qt.	4⅞	3½	5¾
	1 pt.	3	2⅛	4½
	½ pt.	2¾ ⅞	2⅜	3⅛

TIN CANS.—SIZE OF SHEET, FOR FROM 1 TO 100 GALLONS.

For 1 gallon,	7 by 20 inches.	For 25 gallons,	30 by 56 inches.
3½ "	10 by 28 "	40 "	36 by 63 "
5 "	12 by 40 "	50 "	40 by 70 "
6 "	14 by 40 "	75 "	40 by 84 "
10 "	20 by 42 "	100 "	40 by 98 "
15 "	30 by 42 "		

This includes all the laps, seams, etc., which will be found sufficiently correct for all practical purposes.

PATENT LUBRICATING OIL.—Water, 1 gal.; clean tallow, 3 lbs.; palm oil, 10 lbs.; common soda, ½ lb. Heat the mixture to about 210° Fahr.; stir well until it cools down to 70° Fahr., when it is fit for use.

TO RENDER WOOD INDESTRUCTIBLE.—*Robbins' Process.* The apparatus used consists of a retort or still, which can be made of any size or form, in which resin, coal tar, or other oleaginous substances, together with water, are placed in order to subject them to the heat. Fire being applied beneath the retort containing the coal tar, etc., oleaginous vapor commences to rise, and passes out through a connecting pipe into a large iron tank or chamber (which can also be built of any size), containing the timber, etc., to be operated upon. The heat acts at once upon the wood, causing the sap to flow from every pore, which, rising in the form of steam, condenses on the body of the chamber, and discharges through an escape pipe in the lower part. In this process a temperature of 212° to 250° Fahr. is sufficient to remove the surface moisture from the wood; but after this the temperature should be raised to 300° or more, in order to completely saturate and permeate the body of the wood with the antiseptic vapors and heavier products of the distillation. The hot vapor coagulates the albumen of the wood, and opens the pores, so that a large portion of the oily product or creosote is admitted; the contraction resulting from the cooling process hermetically seals them, and decay seems to be almost impossible. There is a manhole in the retort, used to change or clean out the contents; and the wood chamber is furnished with doors made perfectly tight. The whole operation is completed in less than one hour, rendering the wood proof against rot, parasites, and the attacks of the *Teredo navilis* or naval worm. *German Stone Coating for Wood.*—Chalk, 40 parts; resin, 50 parts; linseed oil, 4 parts; melt together. To this add one part of oxide of copper, afterwards 1 part of sulphuric acid; add this last carefully; apply with a brush.

DRILLING AND BORING HOLES IN GLASS AND METALS.

TO DRILL HARDENED STEEL.—Cover your steel with melted beeswax, when coated and cold, make a hole in the wax with a fine pointed needle or other article the size of hole you require, put a drop of strong nitric acid upon it, after an hour rinse off, and apply again; it will gradually eat through.

BORING A HOLE WITH A BORING TOOL.—In boring a hole with a boring tool, it is usually necessary to drill the hole first, and too much care cannot be taken in finishing. An iron gauge should be made first; it is usually made of a piece of sheet iron or wire. The hole should then be drilled smaller than the size desired, and then bored to the required size, and it is impossible to bore a hole perfect without taking two or three light chips, mere scrapings with which to finish. Holes, in this way, may be bored as nicely as they can be reamed.

BORING HOLES WITH BORING ARBOR.—A boring arbor is a shaft with a set in it, for the purpose of boring holes of great length, and is designed to be used in a lathe. In doing this properly, you must first see if your lathe is set straight; if not, adjust it. Having done this, put the piece of work to be bored in the carriage of your lathe, pass your arbor through the hole to be bored, and put it on the centres of your lathe. Having done this, adjust your work true to the position desired by measuring from the point of the tool, continually turning round the arbor from side to side of the piece to be bored, while you are bolting it to the carriage, and measure until it is perfectly true. Having done this, bore the hole, and take for the last chip only a hundredth of an inch. This makes a true and smooth hole. It is impossible to make a hole true with any kind of a tool when you are cutting a large chip, for the tool springs so that no dependence can be placed upon it.

TO MAKE A BORING ARBOR AND TOOL THAT WILL NOT CHATTER.—Boring tools, when used in small arbors, are always liable to chatter and make a rough hole. To prevent this, the tool should be turned in a lathe, while in its position in the arbor, upon the circle of the size of the hole to be bored, and the bearing lengthwise of the arbor, should be only as wide as the feed of the lathe; for if the bearing of a tool is on the face, the more it will chatter.

WRITING INSCRIPTIONS ON METALS.—Take ½ lb. of nitric acid and 1 oz. of muriatic acid. Mix, shake well together, and it is ready for use. Cover the place you wish to mark with melted beeswax; when cold, write your inscription plainly in the wax clear to the metal with a sharp instrument; then apply the mixed acids with a feather, carefully filling each letter. Let it remain from 1 to 10 minutes, according to appearance desired; then throw on water, which stops the process, and remove the wax.

DRILLING CAST-IRON.—Carbolic acid will increase cutting thirty per cent.

DRILLING GLASS.—Spirits of turpentine will enable a hole to be drilled in glass. Drill must be very hard and used with little pressure. Another way is to smear a coating of beeswax about one-eighth inch thick, remove the size of hole wanted and pour in a drop of melted lead. The hole will instantly drop out.

TO CEMENT BRASS ON GLASS.—For cementing brass on glass the following receipt is recommended by Puscher: "Take resin soap, made by boiling 1 part of caustic soda, 3 parts of colophonium (resin) in 5 parts of water, and kneading into it half the quantity of plaster of Paris. This cement is useful for fastening the brass top on glass lamps, as it is very strong, is not acted upon by petroleum, bears heat very well, and hardens in one-half or three-quarters of an hour. By substituting zinct white, whitelead, or air slacked lime for plaster of Paris, it hardens more slowly. Water attacks only the surface of this cement.

To Count the Revolutions of a Shaft.—Several rough-and-ready methods of ascertaining the number of revolutions of a shaft are known to engineers, but the following one, suggested in the "Manufacturer and Builder," by M. C. Meigs, of Washington, is so simple, ingenious, and, when carefully conducted, so accurate, that we are sure its reproduction here will interest our mechanical readers.

A lead pencil is tied fast to the end of the shaft whose revolutions are to be counted, in such a manner that it shall describe a circle of convenient size for observation. If, now, a piece of paper be held lightly against the pencil, the motion of the pencil will describe a circle on it. If, however, the paper be moved backward and forward while the contact with the pencil is maintained, the pencil will describe a series of loops intersecting each other. By timing the period of contact, and then counting the number of loops recorded on the paper, the number of the revolutions of the shaft will be given with close approximation to the truth.

Calculating Speed of a Shaft by Cancellation.—The general rule for obtaining the speed of any shaft that is driven by a series of pulleys or gears from a shaft of known speed, is to multiply the known speed by the diameter of all the drivers, and divide this product by the product of all the diameters of the driven, and the quotient will be the speed of the last shaft. The quickest and easiest way to perform this operation is to put it in the form of a long fraction, with the drivers for a numerator and the driven for a denominator, and then shorten the work by cancellation. Thus, if we had a shaft with a speed of 180 revolutions on which was a 48 in. pulley driving an 18 in. pulley, and on the shaft with this was a 32 in. pulley driving on to a 10 in. pulley, we would place the fraction in this form:

$$\frac{180 \times 48 \times 32}{18 \times 10} = 1{,}536 \text{ Rev.}$$

The 18 and 10 in the denominator will cancel the 180 and leave only the product of 48x32 = 1,536. The slip of the belt would, in ordinary conditions, leave the speed 1,500 revolutions. In the case of gears it is simpler to use the number of teeth instead of the diameters.

TABLE FOR CALCULATING HORSE-POWER OF ENGINES.

It will be seen that the horse-power at any speed of piston can be had, while the ordinary rule is computed from a given speed and steam pressure.

The following table of horse-power constants will be found convenient in figuring the power of engines with cylinders of from four inches in diameter to sixty inches in diameter for one hundred feet of piston speed a minute and one pound mean effective pressure. To figure the horse-power multiply the constant in the right hand column by the number of feet the piston travels per minute, will give the horse-power constant for the number of feet traveled, then multiply by the pounds of mean effective pressure. The quotient will be the *indicated* horse-power of the engine:

Diameter of cylinder in inches.	Piston speed 100 feet a minute.	Diameter of cylinder in inches.	Piston speed 100 feet a minute.	Diameter of cylinder in inches.	Piston speed 100 feet a minute.
4	.038	17	.68475	50	5.950
4½	.048	18	.77075	52	6.432
5	.06	19	.85650	54	6.94
5½	.072	20	.95175	56	7.462
6	.8550	22	1.15175	58	8.006
6½	.10225	24	1.37050	60	8.566
7	.11650	26	1.60875		
7½	.13350	28	1.86550		
8	.152	30	2.142		
8½	.172	32	2.436		
9	.19250	34	2.746		
10	.238	36	3.084		
11	.288	38	3.436		
12	.34150	40	3.808		
13	.402	42	4.198		
14	.466	44	4.606		
15	.53275	46	5.036		
16	.609	48	5.482		

Indicated horse-power for each pound average pressure on a square inch, with different diameters of cylinder, and one hundred feet of piston speed.

ENGINE FOUNDATIONS.—There is not a detail in engine construction and operation that merits greater consideration, or is of greater importance to the successful working of an engine than the foundation upon which it stands, and too much care cannot be accorded it, that it shall have ample spread, stiffness, unity and adaptability to the movements and operation of the parts which it supports. It should be so bonded and tied that unequal settlement shall not take place, and the height, weight and base should be of such proportion that when the engine is in full operation there shall be no swaying or twisting of the parts, no heating of the journals, no springing or tremor of the bed arising for an unsuccessful transmission of the strains. The higher the speed and revolution the stiffer and more solid should be the foundation, and the greater the base contact with the supporting earth. A good foundation will often decrease the defects of a poor bed, provided, of course, that such engine bed be properly and thoroughly bolted to its foundation. When properly constructed and tied together the engine bed and its foundation should be portions of one complete whole, inseparable and undisturbed in their relationship by the movements of the engine parts while at their hardest work.

A good bottom of concrete of smooth upper surface laid upon a rock or solid earth bottom, upon which the main structure of brick is laid close and jointed with first quality of cement, and the whole capped with one or more large blocks of stone jointed and placed to suit the engine bed, and to distribute the weight over as great an area as possible, constitutes the best foundation. Where bricks are scarce the foundation above the concrete may be all of stone, and the larger the stone the better.

Ordinary rubble work is not to be relied upon, the only capacity for retaining and uniting the structures as a whole being contained in the cement. The irregular shape of the stones forming the rubble masonry present, through their lack of contact with each other, rather a precarious and unreliable bond, and the cement is too thinly laid to fix them permanently in their position, in spite of the thrust and twist of engine operation. It is far better to mould a complete foundation of concrete, capping it, if possible, with the thick, solid blocks already mentioned in connection with the brick foundation. The foundation completed and thoroughly set, the engine frame or bed may be placed in position and lined up, and the joints filled and packed with melted sulphur.

The actual nature of the soil or bottom upon which the engine and foundation is to rest, whether it be wet, soft and elastic, whether it be dry, sandy and solid, or whether it be a rock bottom, to which the bed might be immediately fastened with a mere leveling foundation between, determines the nature, extent and scope of the foundation, while the size, weight and power of the engine determines its weight and bulk to prevent vibration or tremor.

HOW TO MAKE A PULLEY.—Many saw-mills are very inconveniently located for access to foundry or supply dealer; besides, just what you want is seldom in stock.

Pulleys up to thirty-six inches and over can be easily made of two pieces of seasoned lumber, the width being one-half the size of pulley, the thickness being the width of face wanted. Cut each to a half circle and with two bolts, one on each side of shaft, cut the center so that it will lack one inch, or about that, of coming together, care being taken to cut center square and true, or pulley will not run true. Then turn the rim off with a good rest, and you have a good, well-balanced pulley, and being split can be put up anywhere. For pulleys over six inches face two pieces spiked or bolted together across the grain, and for heavy service from four to six bolts should be used. The facc of pulley after being turned off true can be covered with leather. I have used 16x36 pulley made in this way. For extra heavy service, the split can be set with key seat in shaft and babbitt metal run in so as to cover bolts. This forms a key that iron would do no good. The metal intersecting the bolts makes a "grip" that's almost impossible to slip.

FOR EVERY-DAY USE IN THE ENGINE-ROOM.—The average weight of anthracite coal is 93.5 pounds per cubic foot.

Coke (loose) weighs 23 to 32 pounds per cubic foot.

Bituminous coal weighs, per heaped bushel, loose, 75 pounds; one ton occupies 48 cubic feet.

Cast-iron weighs per cubic inch, .7604 pounds; in round numbers, one-fourth of a pound to the cubic inch.

Cast-iron will expand and contract between the extreme ranges of temperature in this country with a force equal to 4¾ tons per square inch of surface exposed.

Wrought iron expands and contracts between extreme ranges of temperature equal to nine to one per square inch of section.

One gallon, U. S. standard, contains 231 cubic inches; weight of water in same, 8331; one cubic foot contains 7.4805 gallons of water.

The velocity of steam, of atmospheric pressure, flowing into a vacuum is 1,660 feet per second; into air, 650 feet per second.

To find the pressure in square inches of a column of water, multiply the height of the column in feet by 434.

The proper safe-working load for wire rope is as follows: One-half inch in diameter, 1,000 pounds; five-eighths inch, 1,500 pounds; three-fourths inch, 3,500 pounds; one inch, 6,000 pounds. This is for 19 wires to the strand, hemp centers.

To find the diameter when the circumference is known, multiply the circumference by 3,183.

To find the area of a triangle, multiply the base by one-half of the height.

No. 1 wire gauge sheet-iron weighs 12½ pounds per square foot; No. 2 iron, 12 pounds; No. 3 iron, 11 pounds; No. 4 iron, 10 pounds; No. 5 iron, 9 pounds; No. 6 iron, 8¼ pounds; No. 7 iron, 7½ pounds; No. 8 iron, 7 pounds.

To find the lap required on a slide valve to cut off steam at three-fourths stroke, multiply the stroke of the valve in inches by .250; the product is the lap in terms of the stroke. To cut off at two-thirds stroke, multiply by .289, lead not considered.

HOW TO SUCCEED IN LUMBER BUSINESS.

Run your mill for all it is worth. Keep machinery, belts, etc., in order, and do not stop a minute, if possible. "Time is money," especially when a lot of men are waiting for a small belt to be laced which the foreman should have done the night before.

The mill-man never succeeds who leaves his mill with the whistle sound, unless he has a good, trusty foreman. No business figures out so nice a profit as the lumber business; and how many do we see succeed.

Discard old, wornout, second-hand machinery. There is good second-hand machinery on the market, but be a judge and know the reputation of those from whom you buy.

Have your foreman (if yourself) at the mill thirty minutes before starting up, he first seeing that there will be a good head of steam and plenty of water See that all parts of the machinery are well oiled' saws changed or sharpened. Have engine running at full speed at the sound of the whistle and all hands ready. A thousand feet of lumber will be cut before the incompetent foreman has the mill started. At noon the foreman's duty is to examine all belts and machinery, and repair those that show weakness. Do not take the chances, and probably stop one half hour, to say nothing of some being hurt by broken belt, it having wound around shaft, resulting in a damage of fifty dollars and a stop of a day or so to replace shaft. This may be to the extreme, but such cases have happened.

The dutiful foreman makes his regular rounds. His ear is familiar with the right hum, and detects the least defect. When mill shuts down at night that part is repaired, if it takes one-half the night. This constitutes successful milling, and allows saw-milling to work to figures.

If you have a good foreman, keep him. They are the scarcest of all skill. He will save his wages alone in the prevention of breakdowns and being equal to the emergency in an accident by having everything in its place and knowing where and just what he can substitute. [Not what he wants, as that calls for a machine shop order and a lay-up of the mill.]

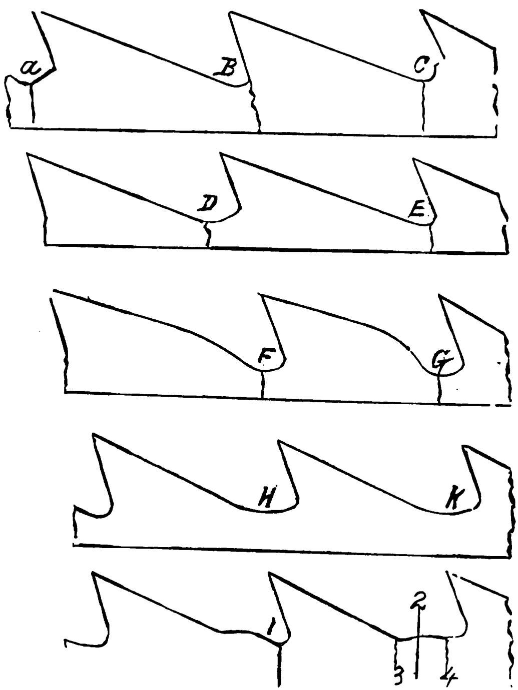
SUPPLEMENT TO BAND-SAWS.

Well knowing that fracture is the principal evil in the band-saw and about the only draw-back toward its perfection, I have made it a particular study and experimented with different shaped teeth, and I find that this has considerable to do with the saw cracking.

The very best steel should be used if a saw is made to last any length of time. Good steel possesses more carbon, which makes it tougher, so that such a saw requires but little temper above the natural steel. Common steel is nearer like iron and has to be tempered much higher, which the steel will not stand, bending and straightening as fast as a band-saw travels.

Band-saws require a special kind of steel. Often low-tempered saws of a fine quality steel soon crack. Since the tooth edge of a saw cracks much quicker, it is evident there is something wrong, and that is, the saw does not bend normally but bends at the extremity of the throat of teeth. This bending in the same place, especially if reduced to a slim, narrow space, is bound to produce a crack. This is overcome by slightly changing the edge of emery-wheel so that this extremity of gullet is changed, which produces a new bending place, thus relieving the steel at that particular place. Thick, heavy teeth tend to make this bending more acute, as shown at *F* of this engraving; also at *B*.

A, *B* and *C* show teeth with square corners. Only *B* produces a crack from this. *A* and *C* do not have the corner at the extremity; therefore saw will not crack there, but as shown at the bottom of throat. *D* shows a very good tooth, which by dressing the edge of wheel can be changed similar to *E*, which changes the bending as indicated by the cracks. *F* and *G* are bad forms. *H* and *K* are good shaped teeth for a band-saw. The bending strain is not confined to so short a space and is easily changed, as there is a slight difference between the teeth. Tooth 2 shows the bending strain at 3 and 4. If such a shape could be conveniently kept with plenty of hook, such a saw would



last well. Some filers run almost a straight tooth. This wears the saw almost square across and keeps bending almost in the same place. Plenty of hook wears the tooth back, which changes that weak place. Some

Saw makers and filers contend that a saw to open in center will crack in center. This cannot be unless in broad saws where the edges are slack. Saws crack from two causes. Too much tension from its strain and the bending over the wheels. A saw may be open but little and crack. This is from the tension being run too close to the edge. This is caused by the miscellaneous use of the hammer on the anvil, that is, removing high places and lumps near the edge.

The opening should be confined to within one to one and one-half inches of the edge according to width of saw. Straighten on a firm wooden slab or block. It takes lighter blows, does not distort the tension nor produce sharp lumps. In straightening the edge, watch that the drop is right and not to near edge.

THE SUCCESS OF THE BAND SAW lies principally in a well fitted tooth, which can not be studied to closely. Most saws have too many teeth. Fewer teeth, short and shaped as 2, will accomplish better results in every way. A short tooth will not tremble. Teeth that tremble loose their corners, and cut irregular waves in lumber. 15 gauge saw should have teeth 1⅝ apart, 14 gauge 1¾ apart; this is based on good swaying and filing. Tooth E. is much longer than 2, but has not the dust room. The shorter the tooth and straighter the throat the longer the saw will last. Saws should be matched closely. A crack at first is very short, but grows unless punched, which should be deeply done with a center punch on both sides. A crack ½ inch long amounts to but little if punched. It soon extends an inch and the life of the saw is gone.

WHAT GOOD FILING WILL DO.—Will let a saw run with less strain on the wheels. Does not require so much tension in saw. Saw will not dodge at the head of the cut, nor "snake" around a knot or tough place. Will stand more feed without shoving back on wheels. All this adds to the life of the saw.

POOR FILING.—Saw will snake, necessitating more strain and tension, which will crack it. Will slip on the wheels and will heat.

Give saw plenty of set; a band saw cannot run with limited set. Saw will drive back by being clamped as it passes through the cut, having the motion of the carriage acting against it.

CRACKED SAWS.—By examining a crack it will show to have begun at the extremity of the gullet which is the point of the bending and strain of the cut. Tooth 2 shows the strain distributed at 3 and 4, which will be more neutral if slightly full as shown. A straight space will be slightly weaker as at H, which by no means is a bad tooth. Close teeth cannot be cut out as 2. They should be 1½ inches apart and more on a 14 gauge saw. Owing to emery wheel passing quickly over throat of teeth, extra precaution should be used. Use only the best wheels.

FACTS WORTHY OF NOTICE ABOUT MAKING A GOOD BRAZE.—Be sure that saw is no thicker at laps, or braze will soon give away. Have saw clamped and irons hot (to a good cherry red), apply acid between laps, leaving the upper lap so as to spring up and down a little. Apply solder and dilute again with acid that the laps and solder be well covered. Apply irons quickly, clamp instantly and you will have a good braze. Both laps and solder must be absolutely clean, not a touch of the finger. Use charcoal for heating irons, which must be a trifle wider than the lap and square to hold sufficient heat. All solder is not alike and a good quality is often hard to get. Some will melt at a cherry while another may require a bright cherry.

Some solder will not adhere if irons are only a trifle too hot. Good quality will stand more heat and will not go to dross. I mention this because I had trouble with different grades of solder.

I mention the precaution from the fact that the instructions laid down by sawmakers helps a filer but little in this delicate work

J. H. MINER.

CONTENTS.

PART I.