A HISTORY

OF THE

PLANING-MILL

WITH PRACTICAL SUGGESTIONS

FOR THE

CONSTRUCTION, CARE, AND MANAGEMENT OF WOOD-WORKING MACHINERY.

BY

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"KNOWLEDGE IMPARTED TO OTHERS IS NOT LOST TO HIM WHO IMPARTS IT."

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All of My Friends,

ESPECIALLY THOSE ENGAGED IN THE MANUFACTURE, SALE, AND USE OF WOOD-WORKING MACHINERY, AND PARTICULARLY THOSE WHOSE LIBERAL PATRONAGE AND FRIENDSHIP HAVE BEEN BESTOWED UPON ME IN YEARS THAT ARE PAST,

THIS BOOK

IS RESPECTFULLY DEDICATED BY THE AUTHOR.

PREFACE.

THE writer has no apology to offer for presenting to the public this work on the care and management of planing-mill machinery. The forty years or more during which he has been identified with it—for thirty of which he has been actively engaged in its manufacture exclusively—is considered sufficient. In September, 1886, he went out of business as a practical manufacturer; yet he cannot say that he does not still take an interest in it. The familiar hum of the planing-mill is still pleasant to his ear, and brings up grateful recollections of the past, and reminds him of the many warm friends that he had, and still has, among wood-workers all over the country. During that long experience and intimate relation with some of the oldest planing-mill men, a number of whom have long since gone to their rest, he was enabled to obtain many of the incidents and facts given in the following pages. The long experience of the author in its manufacture, sale, and use forms the basis of those suggestions for the construction, care, and management of planing-mill machinery; and if they should be found of practical use to those less experienced, then this work, which is dedicated to all users of such machinery, will not have been written in vain.

That such may be the case, is the sincere wish of the author.

ROCHESTER, N. Y., December 7, 1888.

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HISTORY OF THE PLANING-MILL.

CHAPTER I.

EARLY INVENTIONS, IMPROVEMENTS, ETC.

THE history of the planing-mill, like many other useful machines, may be traced back in its rudimentary form many years before its individuality as a distinct and complete machine was fully recognized. We find, by a careful examination of old mechanical works published both in England and France that, many years before William Woodworth made his invention, machines of a similar character were used for working wood into various shapes; and among these different machines one can readily discover nearly all of the elements from which the planing-machine originated.

It is a well-known fact, and one that is recognized by all inventors, that, as a rule, no one man ever originated and perfected an entire machine without embodying in it some of the conceptions of a previous inventor. The first inventor may conceive and carry out, to a certain extent, an idea which to him may appear to be perfect and original in all its parts, and succeed in accomplishing the object in a manner satisfactory to himself; but as one idea always suggests another, the second inventor may take the same elements and commence practically where the first left off, and not only improve upon that idea, but add other ideas of his own to it which the first inventor never thought of, until finally, by the skill and efforts of a series of inventors, the machine becomes perfected in all of its parts.

In some of the earlier inventions in England for the purpose of planing lumber, the stationary knife, in imitation of the hand-plane, seemed to be the prevailing idea; either by a reciprocating motion of the knife, or by forcing the lumber by suitable mechanism under a stationary knife set in an adjustable stock in order to accommodate the various thicknesses of the lumber to be planed. As these machines appear to have been experimental, and never came into general use, it is probable that there were certain mechanical difficulties attending them which could not be overcome so as to render them fit for practical use.

In some of the old machines where the rotary cutter-head was used, the head was attached to a mandrel much in the manner as the circular saw of the present time, and the stuff to be planed was pushed by hand, either over or under the cutter-head, and held down to the table by blocks or springs much in the same manner as the hand-jointer or buzz-planer of the present time. It seems that this style of planing light stuff was in use as late as 1836, when it was determined to build the great conservatory at Chatsworth, when Mr. Paxton, the architect and contractor, says, "he found it desirable to contrive some means for lessening the great amount of manual labor required in making the immense number of sash-bars required for that purpose."

On visiting all the great work-shops of London, Manchester, and Birmingham, the only apparatus which he met with was a grooving-machine. This he obtained, and fitted up at Chatsworth, in connection with a steam-engine, and subsequently so improved it that he could make sash-bars on it complete. This machine, he says, effected a saving of £1400 in the expense of the conservatory. The length of each bar was forty-eight inches, and the original cost of the machine, including the table, wheels, etc., complete, was £20. The attendants required were only a man and a boy. The sash-bars could be made any shape by changing the saws. The bar was presented to the saws below the centre of motion, and to the teeth of the saws which were ascending from the table. "A velocity of *twelve hundred revolutions per minute* was required to finish the work in a proper manner, and *four feet* per minute could be produced in this manner."

In 1850, when the great exhibition building in London was constructed, a similar machine was used by Messrs. Fox and Henderson, the contractors, for forming the gutters for the same. Mr. Henderson, however, made some improvements, by adding cutter-heads, so that, instead of using one head and passing the stuff through the machine four times, he applied four heads, so as to finish the work on all four sides by once passing it through the machine. The timber was first squared up to the proper size by a machine invented by Mr. Furness, and known at that time as the Furness planing-machine. In a description of this machine by Mr. Paxton, he says: "In this machine, cutters were attached to the ends of an arm revolving with great rapidity in a horizontal plane. The timber was wedged up in a frame travelling upon rails, and as this was passed under the revolving cutters, the upper surface is planed off, the timber being held down upon the frame by a large iron disk." He does not state whether the frame was moved automatically or pushed along by hand; but the operation of the cutters and their application to the work was much on the same principle as the Daniels planer of the present time. In a description of the gutter-cutting machine, he says: "Cutters were used instead of saws, and were attached to a cast-iron block by means of bolts and nuts. Four such blocks were required to form the gutter, and were fixed to four separate spindles, and, by the action of drums upon them, were set in rapid motion by means of bands. A piece of timber exposed to the action of these cutters must evidently be scooped out into the form of the outline of the cutters. Any great variety of section can be given to the timber."

It would seem, from a further description of this machine, that some kind of automatic feed was afterwards attached to it; for further along in his description he says: "The piece of timber is placed upon a roller, and pushed onward until it comes in contact with another roller, furnished with projecting points, which seize it and *help* to propel it forward, causing the timber to move much steadier than before, the timber at the same time being held down to the cutters by a hold-fast." After all of these improvements were completed, he says: "By this machine, *three feet* of gutter would be made per minute. This machine was a modification of the same one which was used by Mr. Paxton at Chatsworth for making sash-bars; and the improvements were made by Mr. Birch. In Mr. Birch's improved machine, cutter-heads were substituted for saws, and, by the addition of cutter-heads acting on each side of the stuff, all sides of the piece were worked simultaneously. A cut of this machine is shown in Tomlinson's "Cyclopædia," published in 1851, which, however, only represents one pair of four-sided cylinders, one above the plank and one below it, each having four separate cutters attached, and each cutter having the outline of that particular part of the sash-bar which it is intended to work; so that the pieces, when stuck, contained a section equal to four bars. Behind the cylinders were five circular saws, attached to one arbor and placed far enough apart to correspond to the width of each bar and divide it, after passing the cylinders, in just the proper places to form four perfect bars at one operation. This cut also represents two feed-rolls, one on each side of the cylinders acting upon the upper side of the lumber; but whether there were rolls below or not, the cut does not show; but, judging from its appearance, the probability is that there were none, and that the stuff passed over a table and was propelled forward partly by the action of the rolls with some help from the operator. It required about two hundred miles of sash-bars, according to the report, to complete the building; and as the contractors, Messrs. Fox & Henderson, had bound themselves in a contract to complete the building in four months, it was thought by many to be a gigantic undertaking to furnish that quantity of sash-bars in so short a time. The work was accomplished, however, and Mr. Birch obtained an enviable reputation for his skill and energy. The report does not state just how long he was in completing the job, but simply states that the sash-bars were all finished in time. Now, suppose we give him three months, of twenty-six days each, and ten hours to the day: it would then only require a feed of about five feet per minute to complete the work. The report, however, says that "This *powerful* machine worked with untiring energy night and day until the work was completed." If such was the case, the probability is that the feed did not exceed two feet per minute.

CHAPTER II.

AUTOMATIC FEED-ROLLS—WILLIAM WOODWORTH—HIS FIRST MACHINE—PLANING-MILL MONOPOLY COMMENCED.

Having traced the progress and development of wood-working machinery in England down to the time of the building of the great Crystal Palace, or exhibition building, and noting the machines that were in use at that time, it would seem that, if other and more improved machines were in use or known at that time, Mr. Paxton, the architect, or Messrs. Fox & Henderson, the contractors, would have called them into requisition; as the immense quantity of material that required to be dressed in so short a time as was allotted to them to complete the work of so large a structure would have warranted them in adopting the latest and most approved machinery for that purpose, which no doubt they did. It is very doubtful whether rotary cutters were known or used either in England or France previous to 1826; and even if they were, there were no attempts to combine their use with automatic feed-rolls until long after this time. The first attempt of this kind in this country that we have any record of was a machine invented by Hill; but, from some imperfections in its construction, after repeated trials it was abandoned and passed into the list of abandoned experiments.

About the same time William Woodworth, an old carpenter residing in Poughkeepsie, N. Y., and who was familiarly known among the carpenters as "Uncle Billy," was experimenting upon the same thing in an old saw-mill situated in the lower part of the town, near the river, and not far from where the old Whaling-dock was afterwards located. The old mill and Whaling-dock have long since disappeared, but their location will no doubt be still remembered by some of the older residents of that beautiful city upon the Hudson.

His first machine was patented December 27, 1828. In this machine there was no other device for holding the lumber down to the bed while being planed except the feed-rolls; but as they were placed very close to the cutter-head, they answered the purpose very well, except upon the ends of the boards as they entered the machine before reaching the second pair of rolls located on the other side of the cylinder. The same difficulty was experienced with the latter end of the board as it passed out of the machine after leaving the first, or leading-in, rollers. This had the effect of causing about six inches upon each end of the board to be planed thinner than the middle; and in order to use it in laying floors so as to present a uniform, smooth surface, it was necessary to cut about six inches off both ends of the piece.

After the side-cutters were introduced and applied to the machine, it became necessary to move the feed-rolls farther apart in order to make room for them; then the difficulty became so great that it was found necessary to introduce another small roll immediately behind the cylinder, to overcome this defect. It is quite evident that this small roll was not introduced until some time after the patent was granted; for in the original specification and drawings there is nothing shown or described to indicate that this was any part of the original invention; and being, as it proved afterwards, so important an element in the combination, if it had been known at the time it would have been shown in the drawing and mentioned in the specification.

In describing his invention he says: "The first of my invention relates to the combination of rotary cutters and feeding-rollers in such a manner that the said feeding-rollers shall be capable of feeding the lumber to the cutters, and also of effectually resisting the tendency of the cutters to draw the lumber upwards towards them; the object of this part of my invention being to reduce the lumber operated upon to a uniforinity of thickness, and to give it a planed and even surface upon one side thereof. The second part of my invention relates to the combination, with feeding-rollers and rotary cutters, for planing one of the principal surfaces of the lumber; and of rotary matching cutters so as to form a tongue or groove, or both, upon the edge or edges of the lumber at the same time that one of its principle surfaces is planed." This patent, under the conditions of the old patent law, was granted for fourteen years, and expired December 27, 1842, but was extended for a further term of seven years under a provision of the same law which provides that, upon the expiration of the original patent, if the patentee could show, to the satisfaction of the commissioner of patents, that he had used due diligence in bringing his invention before the public, and that he had not been able to realize a sufficient compensation for his time, labor, and expenses in introducing it, he was entitled to a further extension of seven years.

It is very doubtful whether William Woodworth had made any money out of his invention up to this time. The feeling among the journeymen carpenters was so strong against it that, when the first machine was put in operation, the old saw-mill in which it was located had to be watched constantly both day and night for several months to prevent them from burning it down. Another reason was the want of means to introduce it. Mr. Woodworth having but little means to begin with, and that had all been spent in perfecting his invention, and as almost every one looked upon it with suspicion, as is often the case with other new inventions, the consequence was that very few planing-mills were in operation at that time.

After the patent was extended, finding that he could not interest capitalists into it and obtain the necessary means to successfully introduce it to the public, he determined to sell it out for what he could get. He finally succeeded in selling it out to three or four different parties, who were each assigned a certain territory. It is not definitely known just what he realized from the sale of this valuable patent, but it was reported at that time that he realized in all about five thousand dollars. The New England States were assigned to Samuel Schenck, the Middle States to John Gibson, of Albany, N. Y.; and the Western States to Samuel Pitts, of Detroit, Mich. These parties were all men of considerable means, and at once began to take the proper measures for introducing it among the lumbermen in their respective territories. Gibson started a large shop at Albany for their manufacture, and also a large planing-mill where machines could always be seen in successful operation.

The owners of the patent must have discovered some defect or weak points in the original patent, one of which was no doubt the small roll behind the cylinder, which was indispensable for the successful working of the machine. In July, 1845, the original patent was surrendered and a reissue obtained; and in the reissued patent the small roll is not only shown in the drawings, but is also mentioned in the specifications and claims in combination with the other original elements. From this time, the prejudices of the workmen and their opposition having ceased, the demand for planing-machines increased rapidly, and hundreds of mills were started in different localities, principally, however, in the cities and large towns.

The owners of the patent, it would seem, must have had an understanding with each other not to sell any territorial rights, and only to license a certain number of machines for each city or town, giving each mill-owner the exclusive right for a given amount of territory, for which they were required to pay a certain royalty on each thousand feet planed. They also regulated the price to be charged to their customers, binding them in a contract not to vary from that price under penalty of forfeiting their license. The price in the State of New York was fixed at seven dollars per thousand feet for planing and matching, and the royalty for each thousand feet so planed and matched was three dollars. What the prices were and the royalties paid in other territories is not distinctly known; but probably it did not vary much from the amount just mentioned. Each mill-owner was required to render an account every three months for the amount of lumber dressed, and verify the same under oath, and pay the royalty thereon within ten days from the date thereof.

This, it will be seen, soon created almost a complete monopoly in the lumber business—at least as far as dressed lumber was concerned, for every planing-mill owner had a lumber-yard attached; and, while the cost to him for planing and matching his own lumber was but a small sum over what he paid as royalty, his neighbor was shut out from obtaining a planing-machine, and was obliged to pay seven dollars per thousand for all the dressed flooring he sold. In some of the large towns, when it was thought there was sufficient business to warrant it, two mills would be allowed; and in that case the monopoly of the lumber trade for that town would be divided between the two. But as the owners of the patent controlled the prices, there was no opportunity for competition between them so far as the price of planing was concerned.

This state of things naturally stimulated inventive genius to endeavor to invent devices for accomplishing the same work and avoid the Woodworth patent, which had already become such a monopoly. Among the most prominent of those devices was the machine patented by Joseph E. Andrews, November 1, 1845. In this machine, rotary cutters were used, but the original drawings represent two endless aprons, one each side of the cylinder and working above the lumber for the purpose of holding it down; while below, another endless apron extended the whole length of the machine, passing under the cylinder, and upon which the board rested. This was intended to evade the patent by dispensing with the feed-rolls, thereby breaking up the combination. Flat pressure-bars, one each side of the cylinder, were applied to prevent the board from vibrating while being acted upon by the cutters. The endless aprons as a reliable feed proved a failure, and they were abandoned, and feed-rolls were substituted for feeding purposes, retaining the flat pressure-bars for holding down the stuff.

Although Andrews claimed that, dispensing with the roll for holding down the lumber, and substituting the flat pressure-bar, the same elements of the Woodworth combination were not used, and the ruling of the courts in cases of claims that were combinations was that, in order to infringe a combination claim, precisely the same devices and elements must be used, under these rulings, Andrews claimed the pressure-bar as a new element, and consequently a new combination.

Suits, however, were commenced as soon as this machine was put in successful operation, for infringement, which were decided against it in every case. Judge Blatchford, in deciding one case, makes use of the following language: "The substitution of smooth plates of iron, operated by springs or screws, to press down the boards upon the bed while being planed, in place of a pressure roll or rolls, is not a substantial departure from the Woodworth device for the same purpose" (see Gibson *vs.* Betts, 1 Blatchford, 164; N. Y. 1846: also Gibson *vs.* Harris, 1 Blatchford, 170; N. Y. 1846).

The courts in every suit having decided against the Andrews machine, it was evident that a successful working machine with rotary cutters, without feed-rolls, could not be produced. Inventors then turned their attention to other devices; and prominent among them was the planing-machine invented and patented by Joseph V. Woodbury in the year 1849. In this machine, the knives were fastened to a stationary knife-stock, placed at about the same angle as a hand-plane and provided with a cap or double iron much in the same manner. The lumber was forced through the machine, and brought in contact with the knives by a powerful train of feed-rolls. In some of them there were as many as six knives, so arranged and set that each knife cut off a certain amount of the stock, the last knife taking a very fine cut, so as to finish the surface and leave it smooth.

This machine was quite expensive, and required extra care and skill to operate it. On dry, straight-grained, clear lumber it performed excellent work; but with cross-grained, knotty lumber the work was not so successful, and those that were in use were abandoned as soon as the Woodworth planer came into general use without the payment of royalty.

CHAPTER III.

OTHER INVENTIONS—MORE SUITS FOR INFRINGEMENTS—THE PATENT RENEWED BY SPECIAL ACT OF CONGRESS—THE NORCROSS PLANER—THAT PATENT SUSTAINED.

THE excessive royalty demanded by the owners of the Woodworth patent still acted as an inducement not only to inventors to discover some machine that would do the work without infringing this patent, but was also an inducement to that portion of the public outside of the monopoly to encourage them by purchasing those machines in order to get rid of the exorbitant prices demanded for dressing their lumber.

In addition to the machines heretofore mentioned, there was the McGregor machine, patented in 1846. The Beckwith and the Gay machines, in Pennsylvania, were gotten up about the same time, besides the Brown machine, in Massachusetts, each with its own peculiar devices, which were supposed to evade the Woodworth patent,—all of which were stopped by injunctions and declared infringements soon after being put in operation.

In the mean time the Norcross machine was put in use; and this was the first and only machine among the whole number that stood the test of a suit and was decided not to infringe the Woodworth patent. But as we shall have occasion to refer to this machine hereafter, we leave it for the present.

As the time was drawing near when this patent would expire, and as the owners had all made large fortunes out of it, it was natural to suppose that when the time expired, which would be in 1849, it would be allowed to die a quiet and peaceful death, the owners would retire, and the monopoly would come to an end. But the public were doomed to disappointment. The owners, although all of them had made large fortunes out of the patent, were not yet satisfied; and, as they were men of considerable influence, their money and influence together had been quietly at work for more than a year previous to this time for a further extension. It was too good a thing to allow it to die a natural death if money and influence could prolong its life for another term of seven years; and while the public, or at least that portion of it interested in planing-mill machinery, was quietly waiting for its death, the most skilful physicians in the shape of lobbyists were employed and furnished with unlimited means for prolonging its life. How well they succeeded may be found in the special act of Congress which fastened the same monopoly upon them for another term of seven years. There was rejoicing among the monopolists—not only the owners of the patent, but also the owners of planing-mills which were so situated as to monopolize the lumber trade in certain localities. These men had also liberally contributed, both in money and influence, to bring about this event; and many were the wine-suppers given on this occasion. There was cursing and gnashing of teeth among those outside of the ring, to commemorate this event, also. It was currently reported at that time that John Gibson, of Albany, N. Y., who was reputed to have been worth over one million dollars, and who spent nearly the whole winter of 1848 and 1849 in Washington, contributed, in one way and another, over two hundred and fifty thousand dollars for that purpose as his share of the *necessary expenses* attending it. And if this was true, and others who were interested as well as himself contributed as liberally as he was reported to have done, somebody, either in or out of Congress, must have made "some pin-money for their wives, you know," for of course no one in Congress at that time would be suspected of taking any money to influence their vote. Oh no!

As before stated, from the time of the reissue, in 1845, there had been repeated attempts made to break down the reissued patent; and many suits were defended upon the plea that in the reissued patent there were new elements introduced that were not shown or described in the original patent, one of which was the small pressure-roll behind the cylinder to hold down the lumber while being planed, especially at the ends as the boards were entering in or passing out from between the feed-rolls. It would seem as if this point should have been a good one fort for the defence; as the records of the Patent Office, both in the original drawing and model, do not show it, neither do the specifications mention it. But notwithstanding this and the plea of irregularity in the assignment which was presented and argued by able counsel in the suits of Brooks *v.* Becknell in Ohio, Washburn *v.* Gould, and Woodworth *v.* Wilson, with several others on record which might be referred to, in every case the claims of the reissued patent were sustained and judgments taken against the defendants.

The Norcross machine had now made it sappearance; and the owners of this patent were manufacturing this machine openly, and putting it in the market in defiance of the claims of the Woodworth monopoly. Suits were, however, commenced against it for infringement at a later date and but a year or two before the extended term of the Woodworth patent would expire.

After a short trial, to the surprise of every one who was any way familiar with planing-machines, it was decided that the *Norcross machine did not infringe the Woodworth patent.* The court which rendered that decision must have looked through something else than his glasses if he examined the machine personally; otherwise he would have discovered in the aforesaid machine more of a direct infringement than many others which had been stopped by injunctions.

The claims of the Woodworth patent, it will be remembered, were for the combination of feeding-rollers and rotary cutters. Both of these elements were used, precisely in the same manner, by Norcross; the only difference in the machines were, Woodworth's planed on the upper side of the board, while the Norcross cylinder was below and planed upon the under side of it. But as far as the arrangement of feed-rolls was concerned, there was no difference whatever in the two machines.

As many of the younger planing-mill owners, as well as operators, may not remember the old Norcross, I submit a brief description of its construction and operation.

Upon a frame very similar to the Woodworth machine was mounted one pair of feed-rolls somewhat larger in size than those used by the latter machine for the same purpose. Both upper and lower rolls were geared together by the same old-fashioned system of "star or finger gears," as they were called, and which allowed the rolls to expand or contract sufficient to accommodate the varying thickness of the same lumber, and the top rolls were forced down upon the stuff by the same system of weights and levers. When the machine required changing for the purpose of planing thicker or thinner lumber, different-sized gears were provided, and were changed from time to time, as frequent as the thickness of the lumber required it.

Behind these rolls, and in as close proximity as possible, was the bed-plate, reaching across the machine, the ends resting upon the frame, to which it was securely bolted. This bed-plate was provided with an opening, or slot, running lengthwise with it across the machine, similar to the bed of the bottom cylinder in a modern-style planer, and the cylinder was placed underneath it, the knives working through the aforesaid slot and acting upon the under side of the board substantially the same; the lumber being held down by a heavy press-plate resting upon it.

Instead of the cylinder being fixed to the frame, or permanently attached to the bed-plate, as in the under cylinder of the modern planer, provision had to be made for the varying thickness of the lumber and to reduce it all to the same thickness. In order to accomplish this object, the cylinder-boxes were attached to the upper press-plate, which rested upon the upper, or rough, side of the board and was secured to it by means of arms passing down through the main bed-plate, to which the cylinder-boxes were attached.

It will be seen, by this arrangement, that the distance between the upper press-plate and the cutting-edge of the cylinder-knife must determine the thickness of the board after being planed.

To adjust the machine for planing the several different thicknesses of lumber, cast-iron blocks, or, more properly speaking, parallel strips which were planed the right thickness, were furnished and inserted between the points where the upper press-plate was connected to the cylinder-boxes, and the whole securely fastened by bolts passing through the whole; thus forming a strong frame, and, working in heavy, strong uprights, into which they were nicely fitted, left it free to work and allow the cylinder to rise and fall according to the varying thickness of the lumber, at the same time gauging the thickness according to the thickness of the blocks.

Here was the direct combination of feeding-rollers and rotary cutters just as perfect as could be found in the Woodworth machine; and when suit was brought against it, even the parties who had purchased and were using it expected to be stopped by injunctions, and openly expressed their opinion that their machines were direct infringements, and that it would only be a question of time when they would be compelled to stop. But as the owners of the Norcross patent were men of undoubted responsibility, and had bound themselves in a contract, with each party sold to, to guarantee them against all costs and damages in case of suit and they were defeated, so the only course for the mill-owners was to run as long as they could and make all they could out of it while it lasted, and then look to the owners of the Norcross patent to indemnify them for future damages.

No one was more surprised at the decision of the court than these same mill-owners, many of whom had been estopped by injunction from using the Andrews and other similar machines. It would have been a hard matter to have made some of those old planing-mill men, who were well posted with nearly all such devices, believe that the whole thing was not a put-up job between the owners of the respective patents.

The fact was, the Norcross patent had passed into the hands of men who had wealth and influence; and the owners of the Woodworth patent had in contemplation another effort for a further extension of their patent, and they feared the influence of the Norcross interest when that time arrived, providing the latter succeeded against their patent.

The Norcross owners were secretly in favor of an extension of the Woodworth patent, provided they could be left at liberty to manufacture and sell their own machine.

It was admitted on all sides that the Woodworth was far the superior both as to quantity and quality of work, and, while the lumber was planed and matched upon the Woodworth machine at one operation, the Norcross system required two separate machines—one for planing and another for matching.

But people who could not procure a Woodworth machine were willing to put up with those inconveniences rather than pay the exorbitant price of seven dollars per thousand feet for dressing their lumber; and, further, while the Woodworth patent was in existance there would be a steady demand for the Norcross machine for reasons already given. But if the former were thrown open to the public, so that every one who desired might obtain a Woodworth machine without royalty, every one would prefer that machine and there would be no demand for the Norcross—which subsequent events fully verified.

On the other hand, the owners of the Woodworth patent had so many machines in use that were paying them royalty, and would, in all probability, continue to do so after the patent was extended, that the comparatively small number of machines that Norcross would put into the market during that time would do them but little harm so far as their income from royalties was concerned. Besides, as before stated, the Norcross had no matchers attached; and being only a surface-planer, the lumber, after being planed, required to be cut up and run through a separate machine for matching, thus adding, to the cost of dressing, the expense of twice handling.

So it is evident that both parties, each acting from different motives, were in favor of another extension of this great monopoly.

CHAPTER IV.

APPLICATION FOR A FURTHER EXTENSION—FORMIDABLE REMONSTRANCE—DEFEAT OF THE MEASURE—IMPROVEMENTS, ETC.

THE public, however, was not to be duped again by resting supinely upon its back until the enemy had a second time bound it hand and foot.

The manner in which the Norcross matter was settled, with many other things which transpired, created suspicion in the minds of those who were watching the movements of the monopoly; and when it became definitely known that they were quietly moving for another extension, by a special act of Congress, arrangements were made by the lumber-dealers outside of the monopoly with the publishers of the *Scientific American*, a well-known journal with an extensive circulation, and well known to the mechanical community, and which was known to be bitterly opposed to the monopoly or its extension, to print and send out to each subscriber a form of protest against any further extension of the patent.

These documents were accordingly sent out to each subscriber with a request that they not only sign it themselves, but to solicit all who were in any way interested in lumber to sign it also, and return the same to their office by a certain date. These protests were all arranged and attached to a strong printed protest and petition to Congress against any further extension of the Woodworth patent. This formidable document, containing between fourteen and fifteen thousand names, was forwarded to Washington to a trusty member of Congress, who was to present it at the proper time, provided the subject was brought before that body.

Congress assembled December 1, 1856, and the extended patent had but twenty-seven days longer to run before it would expire.

Gibson and others were on hand, backed by a host of the most expert lobbyists and plenty of money, and succeeding so far as to get a bill introduced early in the session to extend the patent for a further term of seven years from December 27, 1856.

But when the remonstrance was presented, about the time when it came up for action, which resembled a roll of carpet more than a public document, they concluded not to read it, but to unroll and measure it, when it was found to contain two columns of closely written names fifty feet long. This formidable document, coming, as it did, from their constitutents in all parts of the United States, without regard to party or politics, was too big a pill for them to swallow, and the result was that the great monopoly was totally routed. And this ended the career of the Woodworth patent.

Gibson, who was currently reported to have spent another quarter of a million in his endeavors to prolong the monopoly, returned to Albany in a frame of mind that can better be imagined than described. He immediately employed an attorney to travel all over his territory and visit every sash, door, and blind factory, besides other mills, which had used anything in the shape of rotary cutters in combination with feed-rolls, whether it be a planer, sticker, moulding-machine, or anything else, and demand a settlement and payment of royalty from the time they had commenced using the same up to December 27, 1856, or to commence suit against them at once.

Previous to this time, no notice had been taken of those small machines for sash and door work. The owners of the patent had confined themselves strictly to planing-mills, and had, by tacit consent, allowed these machines to be run for years without any intimation that royalty would ever be demanded from them; and when it became known that such action was to be taken, it created a profound sensation among that class of wood-workers.

Some parties who were timid in the matter were frightened into a settlement; while others, among whom was the writer, refused, not only to make a settlement, but advised him to invite Mr. Gibson to accompany him to a certain place where the climate was much warmer than Albany. A few suits were commenced; but public sentiment had become so strong against the monopoly that I am not aware of any of them ever coming to trial. And it is not known to the writer just how much money his attorney obtained in this manner,—whether enough to pay his travelling expenses or not,—but one thing *is* well known: that this course of proceedings on the part of Mr. Gibson rendered him so odious in public opinion that, although he had a large stock of planing-machines on hand at his factory in Albany, he could not find sale for them, while other shops which had started in the business were running nights to keep up with their orders. His old customers would buy almost anything rather than have any dealings with him, and he was finally obliged to sell out his business, together with the stock on hand; and they were purchased by Mr. Daniel Doncaster, a gentleman of fine mechanical abilities, and who had for many years acted as his foreman, and was well liked by his former customers. Mr. Doncaster continued the business successfully for many years after. Gibson afterwards retired to a farm in Steuben County, owned by his wife, and died a few years since, comparatively poor.

Mr. Schenck removed his patterns and special tools to Matteawan, N. Y., as early as 1840, and the Schenck machine, as it was called, was manufactured there. But whether there was any arrangement with Gibson for the sale of those machines in his territory does not appear; but from the fact that there were no Schenck machines met with in this State previous to 1856, the supposition is that they were sold east in his own territory or in territory owned by other parties who did not manufacture.

The Matteawan Company, as it was called, continued the manufacture of planing-machines as a part of their business long after the patent expired, and until that company went out of the business by failure. The tools and patterns pertaining to that part of the business went into the possession of John B. Schenck, and the business was conducted by him until his death, when his sons continued it under the firm name of John B. Schenck's Sons.

Mr. Pitts, of Detroit, Mich., was never engaged in the manufacture of planing-machines personally, but allowed his customers who desired to take a license under the patent in his territory to purchase their machines wherever they preferred ; he simply collecting the royalty on the amount of lumber planed by them. He owned and operated a large mill in Detroit, and, later, started one at Saginaw, Mich. Mr. Pitts, although possessed of a large fortune, was a very liberal-minded gentleman and business man, and died about 1870, universally respected by all who were acquainted with him. The writer had considerable dealings with him in 1863–4 by furnishing him a number of machines, and became personally acquainted with him ; and as those transactions were of the most satisfactory character, they are still remembered with pleasure.

Having traced the three original owners of the Woodworth patent to the end of their connection with it, we now return again to the planer as it was constructed by the original manufacturers.

The Woodworth planer previous to 1856, although it had been the bone of many contentions, was still a very crude and imperfect machine, as compared with those of the present time. In fact, there seemed to be no disposition on the part of those engaged in its manufacture to make any improvements : they seemed to carry out the idea that they were good enough ; and, as there was no competition, their customers could take it as it was or do without it. As soon, however, as the patent expired and was open to the public, new manufacturers started, and one improvement followed another, many of which were the subjects of new patents, until the whole machine has become so changed in its appearance and construction that it is a question if William Woodworth, could he return to this earth, would recognize it as the offspring of his original invention.

The planing-machines manufactured by Gibson, Schenck, and others previous to 1856 were provided with straight uprights for the cylinder-boxes, and the cylinder worked up and down as it was required to be raised or lowered for the purpose of dressing thick or thin stuff, and worked at right angles to the frame. With this arrangement, it will be seen that if the belts were of the proper tension for planing lumber three fourths of an inch thick, they would be too short when the cylinder was raised sufficiently above the bed to admit of planing two-inch stuff. The common practice was to keep short pieces of belt the right length to make up the difference; and when it was required to plane thick lumber, these pieces were added to the belts and taken out again when the work was finished and the use of the machine required for thinner stuff.

Again, the finger or star gearing that was used to connect the top and bottom rolls would only allow of an expansion of about one half an inch, and were not practical to use on different thicknesses of lumber; consequently, whenever a change from one thickness to another was required, these gears required to be changed also. There were several sets of them always ready for use, and it was no uncommon thing for the operator to be obliged to change them half a dozen times during the day.

The small pressure-roll behind the cylinder was another very inconvenient arrangement. The adjustment of it was separate from the adjustment of the cylinder, and required to be set every time the cylinder was changed; and frequently the machine would require stopping several times before a proper adjustment of this roll would be obtained. The cylinder-belts, also, ran inside of the frame, which required the width of the frame to be from eighteen to twenty inches wider, in proportion to the width of the cylinder, than the modern machine.

A modern operator of planing-machines would form rather an unfavorable opinion of a machine so constructed that, if a job requiring a few hundred feet of thick stuff to be planed, before he could finish that part of the job, would require both cylinder-belts to be taken off and a piece put in each, then change all the gears upon the feed-rolls, besides stopping two or three times to adjust the small roll behind the cylinder, together with all the rods and screws connecting the top feed-rolls with the weighted levers below, spending perhaps an hour or two in order to put the machine in proper shape to do perhaps one half hour's work, he would not only realize that great improvements had been made in the modern machine, but wonder that they were not made sooner. But, as before intimated, the policy of the owners of the patent were such as to effectually shut out all improvements as long as the patent was in force.

In the machines that were brought out in 1857, the frames were narrowed up so as to allow the cylinder-belts to run outside of the frame, thus rendering them more compact and requiring less room. The uprights which supported the cylinder-boxes were placed at right angles to the driving-shaft, so that, in changing from one thickness of stuff to another, but little, if any, difference was noticed in the tension of the belts. The small roll behind the cylinder was attached to the cylinder-boxes, so that it was adjustable with the cylinder, and, when once adjusted, required no further adjustment when the cylinder was raised or lowered to accommodate the different thicknesses of stuff.

The difficulty in keeping the small pressure-roll in front of the cylinder free from the small particles of gum which accumulated upon its surface, and which marred the face of the planed lumber, led most of the manufacturers to adopt the flat pressure-bar—an old device, which was used many years previous on the Andrews machine. This device was at first objected to upon the supposition that the friction upon the surface would obstruct the feed; but subsequent use proved these objections to be unfounded, and soon after 1857 the pressure-bar came into general use upon all first-class machines.

CHAPTER V.

BROWN EXTENSION-GEARS—OTHER IMPROVEMENTS —BURLEIGH'S PATENT DIMENSION-PLANER — HENRY D. STOVERS CELEBRATED CLAIM.

WE stated in the last chapter that, previous to the time when the Woodworth patent expired, very few improvements had been made upon the original machine. With the exception of the Brown extension-gears, which were applied to it a short time previous, and which superseded the star or finger gears, the machine, in its general features, was about the same as when first completed by the original owners. But as soon as the extended patent expired, the inventive genius of the whole country, or at least that portion of it who were in any way interested, seemed to turn their attention in that direction; and there was no end to the alleged improvements that were brought out and patented within a few years after this event. Some were practical and useful, some really valuable; but a large portion were of so trifling a nature that they were never heard of afterwards, and probably never known to any one but the inventor and the examiner at the Patent Office.

The examiners at the Patent Office at that time seem to have granted about everything that was applied for, without giving themselves the trouble to look up and ascertain whether the thing applied for was new and useful, or whether it had been patented previously or not; as we find, in the time between 1856 and 1860, several patents granted for the same thing, and dated so near the same time that they all must have been pending in the Office at the same time.

One of the earliest patents we notice that came into use was one which was granted to James A. Woodburg, of Boston, Mass., for a plan for moving both matcher-heads by means of two separate screws. As the old Woodworth machine moved one matcher-head by a screw, the simple fact of attaching another screw to the other head for the purpose of moving that also was a mere duplication of parts, and, under the present ruling of the Patent Office, would not be considered an invention, and, consequently, not patentable.

The improved extension-gears invented by Charles Burleigh, of Fitchburg, Mass., and assigned to the Putnam Machine Co., was really a good invention, and was an improvement over the Brown gears, and overcame certain objections to that device. It consisted in forming one end of the links that confined the idle or loose gears to those attached to the roller-shaft in the form of the segment of a circle of the same radius as the idle gears, with teeth or cogs formed upon the outside circumference so as to engage each other; and, when confined in this position by the cross-strap that kept them in gear, when the top roll was raised or lowered to accommodate the varying thickness of the lumber, those links worked together upon the same centre as the gears, thus always keeping them in the same relative position to each other, no matter what the position of the rolls might be.

The dimension-planer known as the Gray & Wood planer was patented January 24, 1860, just about one month after the celebrated Stover patent was issued, which we shall soon notice. The Gray & Wood planer is so well known among wood-workers that a description of it is deemed unnecessary, except so far as to illustrate the loose manner in which the business of the Patent Office was conducted at that time. The Gray & Wood planer, as is well known, is a modification of the old Daniels planer, which had long been in use; and their improvements consisted in the application of a Woodworth cylinder to plane the lumber lengthwise of the grain, instead of the arms of the Daniels, which worked crosswise, using the same sliding table as the Daniels. They also applied feed-rolls so that the lumber could be fed through the machine while the platen remained stationary, or the feed-works could be readily removed and the platen used in their stead when it was desirable to take the lumber out of wind. Their claims were few, and appear to be confined to just what they invented and nothing more.

Now, just about one month previous (December 18, 1860) the Patent Office had granted to Henry D. Stover a patent for the same thing; which not only covered everything which he had invented but everything which others had invented or could invent—principally the latter: and these two claims must have both been pending in the Office at the same time.

While Mr. Gray is somewhat modest in his claims, and seems only to cover what he invented, Mr. Henry D. Stover goes in for the "whole hog." As this patent is such a remarkable one, and deserves to go into the history of planing-mill machinery, we give the claims in full, as a historical curiosity. In the specification he say:

"The claim and engravings will explain the nature of this invention. [No one will doubt that fact when he has read them.]

"First, I claim the combination of cutting-cylinders (*o*) and cross-head (*m*), with two or more screws (*e*) for raising and lowering the cutting-cylinders evenly and parallel to the face of the platen.

"I also claim to so pocketing or encasing the raising and lowering screws (*e*) in the uprights (*c*) that dust and shavings will be effectually excluded, whether the machine is in operation or not.

"I also claim so constructing the cutting-cylinders (*o*) as to receive four or more cutting-blades (*P*), each imparting a shearing or drawing stroke or cut; and, at the same time, for convenience in construction and ease in sharpening and securing the blade to the head.

"I also claim forming the portion of the cutter-head immediately back of the edges of the cutting-blades,—an angle varying from 5° to 45° from the face of the cutting-blades,—to constitute a solidly, variable, and efficient cap to the cutting-blades.

"I also claim so constructing, connecting, and arranging the sliding journal-boxes (*T*) with cross-head (*m*), which carries the cutting-cylinder (*o*), by means of rods (*n*), that, when the cutter-head is raised or lowered, these journal-boxes will move so as to always retain a precisely equal distance between the driving-pulleys and the driven pulleys on the cutter-head for equal tension of the belt.

"I also claim feeding the platen back and forth by friction-slide (*A*), and wheel (*D*), and rack (*B*), and pinion (*C*), for the purpose set forth.

"I also claim reversing the movement of the platen by means of screw (*m*) and wheel (*o*), for forcibly engaging the rack by its pinion on the friction side of its wheel.

"I also claim sliding, moving, and attaching the cross-head (*m*), carrying cutting-cylinder (*o*) on and to the upright (*C*), in and by adjustable slides (*N*).

"I also claim pivoting the journal-box (*H*) for the friction feed-shaft, and giving it a vertical adjustment to both swing and rise or fall with the feed-shaft.

"I also claim *several dogs*, operated independently of each other, to effectually hold several pieces firmly to the platen for dressing, at the same time constructed substantially, as described.

"I also claim sliding the feed-rolls into position for use, and removing them from the machine by means of gib-slides, so that these rolls are always secured for use, and yet allow a free movement, and to require no additional security.

"I also claim suspending and moving cross head for cutting-cylinder by screws (*e*), which are suspended in universal bearings; and by universal nuts to allow a free and untrammelled movement for adjustment and ease in operating, and to secure the cutter-head parallel to platen at any elevation from its surface.

"I also claim a conducting spout or trough (*A4*), so constructed and connected with cross-head or other part as to receive and conduct the shavings from the cutting-cylinder and the machine to any part desired, by means of the current of air set in motion by the great velocity of the cutting-cylinder.

"I also claim an elastic pressure-roll (*D*4) and scraper (*T*4); that either can be used at pleasure, with the elastic pressure-roll, to plane straight and out of wind.

"I also claim the iron uprights (*C*), constructed with cavity or pocket for reception of elevating screws when combined with bed-piece of wood-planing machines, all substantially in the manner, or their mechanical equivalents for the purpose, fully set forth and described."

This patent reminds us of the burlesque patent of the Frenchman and his dog for hunting frogs. The gun was strapped upon the back of the dog, which was a pointer, and when the dog pointed at a frog the Frenchman discharged the gun by means of a line attached to the dog's tail. He first claimed the combination of the dog and gun; second, the combination of the gun and dog; and, finally, he claimed the dog and gun both. If this was not a burlesque, we should say that the claims of one patent were about as reasonable as the other.

With all due respect to the United States Patent Office, we do think that the genius who examined the claims of the Stover patent (provided they were ever examined), and passed them for issue, should have been retired from active service for the balance of his life upon a pension of four dollars per month. There are other patents which we shall notice that are ridiculous enough, but the Stover patent may be placed at the head of the list.

The unsettled state of the country in 1861, and the almost universal depression of every branch of business, seems to have been a check to inventive genius, at least so far as the planing-machine was concerned. In fact, the report of the Commissioner of Patents for that year indicates that the business of the Patent Office had materially decreased in that time. In his report he says:

"The decrease in the number of patents in 1861, as compared with the year previous, was 1479; and that the expenditures for the year exceeded the receipts $84,137.47."

The only patents that we notice for alleged improvements in planing-machines was one granted to Henry D. Stover, which was a rehash of his celebrated patent of 1860, in which he claimed, among other things, "several dogs," which we gave in full in the preceding chapter. This patent of 1861 had *only* ten claims; and if any of our readers should desire to read them, they may be found in the Patent Office reports for 1861, page 437.

CHAPTER VI.

FURTHER IMPROVEMENTS—PATENTS OF WARDWELL—WILLIAM H. DOANE AND OTHERS—THE CHIP-BREAKER—EARLY HISTORY OF THE MOULDING-MACHINE, ETC.

UPON a revival of the business of the country, which commenced early in 1862, inventive genius seems to have awakened; and the planing-machine, as well as other planing-mill machinery, was again a subject for further new and useful improvements.

We notice, however, by a careful review of the business of the Patent Office for this year, that the largest number of patents which were granted were for implements of warfare, which seemed to be the leading subject for mechanical improvements; and the number of patents granted that and subsequent years for devices for warlike purposes exceeded any other branch of business.

The only patents of any consequence which we shall notice at this time which were issued in 1861, was one to C. P. S. Wardwell, of Lake Village, N. H., for planing clapboards; which would appear, from the specification and drawings, to possess some new and useful features as adapted to that particular class of work; still there is no apparent reason why, with a certain modification of the cutters, the same work could not be done on any planing and matching machine.

Another was granted to W. H. Doane and William E. London, of Cincinnati, Ohio, for alleged improvements in combined planing and matching machines.

In their specification they state that "The invention relates to a method of attaching the tonguing, grooving, and matching works of a planing-machine to a sliding bed or ways, so that they can be instantly removed out of the way below the top of the bed upon which the planing-tools operate, and that the same machine can be used for planing either wide or narrow stuff without delay in the operation, and also for tonguing, grooving, and planing at the same time."

There were several claims relating to the particular mechanical devices employed to accomplish this purpose which the inventors were clearly entitled to. But the first claim was too broad, and covered a principle which had already been in public use and on sale for more than two years previous to their application, and, consequently, invalid. This is the only claim which we shall notice. It says:

"First, in a combined planing, tonguing, and grooving or matching machine, so attaching the tonguing and grooving or matching works that they may be adjusted to a position above or below the top of the planing-bed substantially in the manner and for the purpose described."

This claim, when taken in its broad sense, would, as no doubt it was intended to, cover any and all devices for removing the matcher-spindles by dropping them below the bed, so that in surfacing wide stuff it would pass over the top of them.

A device for this purpose, so far as relates to the lowering of the matcher-spindles below the bed when surfacing, had already been in public use and on sale for more than three years previous to this time ; and this device was well known to the writer, and had already been applied to seventy-five or more machines which were in public use. The same was true of many other patents which were issued about this time, none more conspicuous than the patents of Henry D. Stover. In his application he was obliged to swear that he was the original and first inventor of the several devices set forth in his specification and mentioned in his claims. Now, while other inventors might have made the same affidavit—not knowing of the previous use of the same invention—and acted in good faith, believing that they were the original inventors of the devices named, in the case of Stover there would be no question but what he well knew that there was not one single original idea to be found in the whole thing, but was picked up here and there from other machines that had those same devices, and that had been in use in many of them for years previous.

It is a notorious fact, as before mentioned, that the business of the Patent Office was so conducted at that time that all that was required was to get together any number of devices, no matter whether new or old, swear to being the original inventor, make application to the Patent Office in the prescribed form, pay the government fee (which was the most important part of the programme), and in due time a patent would be forthcoming. It seemed to be the prevailing idea with some manufacturers that if they could only secure the authority of the government to mark the word "patented" upon a machine, or an article of any kind, it would insure a ready sale whether the article was good for anything or not.

There is one thing certain: the owners of many of the patents issued about this time never attempted to enforce their claims, for the reason, probably, that they were well aware that, if they did attempt it against others who were using these same devices, the courts would set them aside; so, many of them contented themselves with blustering around and making *terrible* threats, which they never intended to put in force.

From 1862 to 1866, there were a large number of patents granted for alleged improvements in planing-machines; but as most of them were for devices that never came into general use, and our space will not admit of a notice of all of them, we pass over until June 15, 1866, the date of the patent granted to J. B. Tarr, of Chicago, Ill., for a device for protecting the edge of the board while being matched, and which is generally known among planing-mill operators as the "chip-breaker," and applied to the side-cutters. This patent was assigned to S. A. Woods of Boston, Mass., and applied to all subsequent machines of that manufacture. This was really a valuable invention, as all planing-mill operators had long felt the necessity for some such device to prevent the board from splitting and slivering on the edge while being submitted to the action of the side-cutters.

Unfortunately for the inventor, as the patent-laws were construed at that time, the patent was not a strong one. After describing his device—which consisted of what he terms a mouthpiece, which was in the form of the segment of a circle hinged upon a pin nearly opposite the point in contact with the edge of the board, and pressed against it by means of a spring,—he says:

"I claim the construction of the mouthpiece, and the arrangement of the slide and spring in relation to the cutter, substantially as *herein described and shown.*"

This claim, under the construction put upon the law, and the rulings of the Patent Office in similar cases, confined him to the particular manner in which it was constructed, and did not prevent others from using a similar device for the same purpose, provided it was constructed in a different manner from that which was shown and described.

Under this construction of the law, in January of the next year (1867), Mr. S. M. Richardson, of Worcester, Mass., applied for and obtained a patent for substantially the same thing, which accomplished the same purpose. In the Richardson device, instead of swinging the chip-breaker or mouth-piece upon a pin, it was worked in a circular groove, and was pressed against the board by means of a spring. As this was a departure from the manner in which the Tarr patent was shown and described, it could not be held as an infringement of his claims.

There is no doubt but Mr. Tarr was the originator of this device, as there is no record in the Patent Office or elsewhere of any device of this kind previous to the time he made his application; and if his claims had been properly drawn and presented to the Patent Office, a much broader one might have been obtained and worded so as to cover all of the many devices which were adopted by the different manufacturers, and his patent would have been a very valuable one.

But as it was, every manufacturer of planing-machines had a particular device of his own, differing just enough from the original to evade its claims; and after the year 1866, very few machines were sent out from the shops without some kind of a chip-breaker attached to it.

A number of patents were granted to James. A. Woodbury, of Boston, Mass., duringthis and subsequent years, some of which were new and useful. Some were for old and well-known devices which were worked into the claims, and some of so frivolous a nature that they were not worth the paper they were printed upon. one of his patents which we notice, there were a number of claims intended to cover about every piece of the machine, whether new or old; and when he comes to the bottom cylinder, he says:

"I claim the bottom cylinder when placed *at or near the end of the frame*."

It is well known that all bottom cylinders since the days of the Woodworth patent were placed near the rear end of the frame—some forward of the leading-out rolls and some behind them. But, as the owners of this patent never attempted to enforce it against those who placed their bottom cylinder where they preferred, and as each manufacturer continued to put the bottom cylinder just where it suited him best, no court ever had the important question to decide just where "at or near the end of the frame" was; so the public are still in profound ignorance of this important locality.

From this time (1866) down to 1870 there were but few changes made in the planing-machine. In fact, it had by that time about attained to a degree of perfection that required but very few changes; and those improvements which were added from that time—many of which were subjects of patents—were more for convenience in operating and changing than for any other purpose.

Heavy-moulding machines were introduced about this time, and have since become such an important factor in the outfit of a planing-mill that they are fully entitled to be classed under the head of planing-mill machinery. This machine has a history of itself. Starting, out as it did, from a very simple device for working sash-bars, it has worked its way up to its present proportions and usefulness by the changes in modern architecture, and by the skill of mechanical science, stimulated constantly by the demand for a better class of work than could be accomplished by the original machines, and was of such a nature that it could not be done practically upon a regular planer and matcher.

The first attempt that we have any record of in this country for working irregular shapes by machinery, was made by the firm of Fay & Fisher, at Lancaster, Mass., the date of which we have not been able to obtain. This machine, however, proved to be a failure, from the manner in which the cutter-heads were constructed. These cutter-heads were made in the form of a rim, resembling that of a pulley, with a solid plate upon one side. Slots were made in this rim to allow the cutters to project through, which were fastened to the plate on the inside by means of screws.

The idea seemed to be to represent a common hand-plane formed into a circle instead of being straight. These heads were unsafe, and bursted from the centrifugal strain upon them; and after a few had been tested, no one would use them. The same styles of head were applied to a tenoning-machine got up by the same firm, with the same results, and were abandoned.

In 1848, Mr. C. B. Rogers, of Norwich, Conn., commenced the manufacture of wood-working tools, and soon after associated himself with Mr. J. A. Fay, who had now located at Keene, N. H. The shop at Keene was conducted under the firm name of J. A. Fay & Co., while the one at Norwich was under the firm name of C. B. Rogers & Co.; and the first successful working sticker, as it was then called, was got up at the latter place.

It was a very simple affair consisting of a wood frame. The arbor which carried the cutter-head worked upon centres fixed to the frame, running upon points about one half an inch in diameter and about three quarters of an inch long. The feed-works consisted of one fluted roll one and a quarter inches in diameter, placed in front of the cutter-head and forced down upon the stuff by an adjustable spring. This was driven, by a set of wooden cone pulleys, from the back-shaft, so as to reduce the speed and to give the requisite amount of feed. The driving-pulleys were also of wood, attached to the same back-shaft; and this, with a spring to hold down the stuff behind the cutter-head, comprised about all the machinery there was about it. The table was also of wood, and attached to one side of the frame by means of a bolt at each end working in slots in the frame, and was adjusted up and down, to accommodate the different thicknesses of stuff, by means of screws at each end of the table.

The form of cutter head adopted by this firm was what is termed the cap-head; and as this style of cutter-head is still in extensive use with but little change, and is so well known to sash and door makers, a description of it is unnecessary.

This machine, crude as it was, proved to be a success; and hundreds of them were sent out from both shops. The most essential parts of this machine were subjects of patents; and for that reason this firm seemed to have almost a monopoly of this business for a time. Other wood-working machines were added to their list, until the demand for their machines was such that it became necessary to increase their production. A third shop was opened, at Worcester, Mass., and was placed under the management of Mr. E. C. Tainter, who is well known among the wood-workers as an old veteran in that line and by the familiar name of "Eph." Mr. Tainter managed this shop until about 1857 or 1858, when it was discontinued by this firm and passed into other hands; leaving only the original two shops in the possession of this firm, which continued until the death of Mr. J. A. Fay, when the tools and machinery, together with the stock and fixtures, were removed to Norwich, and the whole business concentrated at that place.

In 1863, this firm became incorporated under the corporate name of C. B. Rogers & Co., Mr. C. B. Rogers being its first president, which office he held until his death, when Mr. Lyman Gould succeeded him, and still holds that office; while the active management of the affairs of the business in detail has devolved upon its able and energetic secretary and general manager, Mr. R. W. Perkins.

It is claimed by some that there were moulding-machines made in New York as early as those made at Norwich; but upon strict inquiry we have failed to obtain any authentic account of any shop at that place that manufactured and put upon the market a moulding-machine at that time. We have record, however, of one or two shops which manufactured and sold mouldings about that time; but it appears, from the best information we can obtain, that these machines, whatever their style was, were got up by the parties themselves for their own especial use, and not manufactured or introduced to the public. Just when those machines were put in operation and when they went out of use, we have been unable to learn.

But, to return again to our former subject. The advanced state of the art of building, and a consequent increased demand for mouldings of a different and better design, rendered it not only necessary to work more than one side at a time, but, in order to carry the necessary machinery and perform the work in a satisfactory manner, a much heavier and stronger machine than had been heretofore built was required.

About this time (between 1863 and 1866), the late Mr. H. B. Smith, then of Lowell, Mass., commenced to produce machinery for the manufacture of sash, doors, blinds, and mouldings, making this a specialty; and devoted much time to perfecting his moulding-machine particularly. To Mr. Smith, it is believed, belongs the credit of first introducing iron frames exclusively for this class of machinery. Other manufacturers soon followed, and it was not long after the year 1857 when iron frames were not only applied to this, but to nearly all other, wood-working machines, including the planing and matching machine. Mr. Smith also introduced a much heavier machine than had heretofore been used; and although they were quite light as compared with other machines which a few years later succeeded them, his work became very popular at that time. One of his improvements which he secured by letters patent was attaching the table to the frame by dovetailed slides and gibs, and the raising and lowering of the same was accomplished by one screw located near the centre of the machine, and easy of access.

Previous to 1862, all moulding-machines were built with the overhanging head; and as long as narrow strips only were worked, there was no difficulty in making smooth work. But when the demand for heavier work required wide strips to be used for heavy mouldings, there was a tremble, which manifested itself upon the work, which was very objectionable. Various devices were applied, such as an outside bearing to support the head; but as those bearings were necessarily attached to the table, and required to be loosened every time the thickness was changed, they only partially answered the purpose sought for, and could not be considered a practical device—although some manufacturers are still using it on certain machines.

CHAPTER VII.

THE MOULDING-MACHINE, CONTINUED—THE INSIDE-MOULDER—INTRODUCTION OF THE RESAWING-MACHINE—THE CROSBY PATENT—MYERS & UNISON'S CLAIMS—SUIT BROUGHT AGAINST THE MESSRS. HAWLEY AND MR. DONCASTER—RESULTS, ETC.

THE increased demand for heavy work was such that, in order to meet it, a new departure in moulding-machines became necessary, which required the cutter-head to be placed between the bearings in the same manner as a planer and matcher.

The Lee machine was the first which came into use constructed in this manner. It was got up very light. In the first machines, one side cutter-head was placed in front of the cylinder, while the other was placed behind it. Notwithstanding this machine did not fully meet the expectations of the wood-workers, yet a great many were sold and put into use.

In 1864 and 1865, three heavy twelve-inch inside-moulders were put upon the market—one by C. B. Rogers & Co., of Norwich, Conn.; one by S. A. Woods, of Boston; and one at Rochester, N. Y., by the author. These machines, although somewhat different in construction, were all intended to overcome the objections that had been urged against the Lee machine by the wood-workers, who claimed they were too unhandy to operate successfully.

There is always a certain class of mechanics who are ready to oppose any new departure from the old beaten track; and in this case there was no exception. Some would still argue in favor of the overhanging head, for the reason that they could always have a number of duplicate heads set up for different kinds of work, and it was much easier to change the heads than to change the cutters. But the fine, smooth work turned out by their neighbors, when compared with the wavy and uneven work of their own, soon compelled them to fall into line and use the inside machine for heavy work, or allow the work to go to their competitor in the same business who had one. Besides, its availability was still more appreciated when it was found that when not in use for mouldings it could be profitably employed in planing and matching ceilings, siding, door-casings, and wainscoting to better advantage than the same could be worked upon a planer and matcher.

The introduction, also, of the four-sided slotted head greatly facilitated the setting of the cutters; and the operators soon began to discover advantages which had not presented themselves before. The head having four sides, and provided with caps, sectional cutters could be used consisting of hollows and rounds, square, and other shaped tools, so that a great variety of different shaped mouldings could be stuck with the same tools by simply changing the combination; besides being much easier to keep in order.

The inside-moulder, so called, is now extensively used in planing-mills where large quantities of ceiling are manufactured. As there are no feed-rolls behind the cylinder to draw the stuff out, it requires that the strips should all be of one width, so that one may follow the other in succession; otherwise, whenever it became necessary to change the width, a narrow strip would require to be run in order to push the last piece beyond the side-cutters.

The work on fine ceiling is much smoother than when run on a common matcher, as there are no rolls to pass over the face of the stuff, after being planed, to mar its surface by chips or small particles of gum which are liable to adhere to them.

The modern planing-mill, well equipped in order to meet the requirements of the present time, requires a number of auxiliary machines for fitting and preparing the lumber for use both previous to and after it has been planed. It is true that the mills of an early date, with the limited amount and variety of work which were required of them, only demanded a saw-table for ripping up the lumber to the requisite width; and after being run through the planer, the work was completed, so far as the planing-mill was concerned.

The modern mill goes still further—it not only planes and matches the lumber, but fits it for the different uses required in building; so that when the lumber leaves the planing-mill, there is but little hand labor required.

In speaking of the improvements in planing-mill machinery, and the improved methods of getting out lumber for building purposes, an old planing-mill owner remarked: "A few years ago, if you wanted to build a house, you would employ a carpenter to do the work; but now all you have to do is to get your architect to make your plans, then go to the planing-mill and order your house made, then purchase a few kegs of nails, and hire a carpenter to put it together." This was perhaps putting it a little too strong; but it is a fact that the amount of hand labor which is required to complete an ordinary dwelling-house is very small, in comparison to what it was a few years ago.

One of the early machines that came into use in connection with the planer was the resawing-machine. Saw-tables, it is true, were in use for resawing certain kinds of work, particularly bevelled siding, long before the introduction of the resawing-machine. These were provided with bevelled guides, and springs to hold the stuff up to the guides while the board was fed to the saw by hand. This style of making bevelled siding—or clapboards, as they were called—was expensive, as it required the labor of two men—one to push the board forward, and another at the opposite end to pull it out; besides, the irregularity of the feed would cause the saw to run, frequently, making thick and thin places in the siding, which was an objection to this method. The progress that had been made in working lumber by machinery demanded greater accuracy, and the want was felt of something that would turn out truer work with greater economy of labor.

The Crosby resawing-machine, which was patented in 1842, was intended to supply that want. Its manner of construction was an upright saw, working in a frame similar to an old-fashioned saw-mill. This was mounted upon a suitable frame and provided with an automatic feed. This machine, although very effective and accurate in its work, was slow as compared with the machines which succeeded it, or even with the saw-table with the hand-feed, and did not fully meet the requirements of the planing-mill owners. It is true, the expense of running it was small, as it could be attended by a boy, after being properly set and adjusted; so that, in the end, a much better quality of siding could be made, and at less expense, than by the old process of sawing by hand. This machine had a rapid sale, and in a short time very few mills of any capacity could be found without one.

The claims of the Crosby patent were so broad as to effectually shut off any improvements while the patent was in existence. After describing the machine by the usual specification, he says:

"I claim the combination of automatic feed-rolls with a saw, either circular or upright."

This claim gave him as complete a monopoly as the claims of the Woodworth patent; and, like the owners of the latter, customers could take this or nothing, there being no choice in the matter.

This patent, or the right to manufacture and sell, came into the possession of the late John Gibson, of Albany, while he was manufacturing the Woodworth planer; and the two monopolies worked well together—at least, as far as Mr. Gibson was concerned—while it lasted. Although Mr. Gibson personally was opposed to improvements of any kind, saying that the machines were "good enough," yet, through the influence of Mr. Doncaster, who was his foreman at that time, he consented to allow him to introduce a circular saw on the small-sized machines which were intended for sawing bevelled siding, using the same frame-gearing and rolls.

This machine, which afterwards became known as the "Doncaster machine," soon superseded the upright, and was manufactured and sold for several years before the Crosby patent expired, and long after Mr. Doncaster became the successor of John Gibson. Up to this time no attempt, so far as we can ascertain, was made to cut anything wider than six or eight inches, and a saw twenty-two inches in diameter was about the largest size used, which was ground to an even thickness of about 13 gauge.

The demand for a machine to cut wider stuff led to the introduction of the taper-ground saw; as a straight saw of sufficient diameter to cut wide stuff would necessarily require to be so thick that there would be but little economy in its use. Upon the introduction of the taper-ground saw, another change was required, in order to relieve the centre of the saw from the pressure upon its sides while the stuff was passing over it. This was met by Mr. Doncaster by introducing two small plates, one on each side of the saw, and firmly attached to the bed-plate, so that, when the lumber that was being sawed came in contact with those plates, it was sufficiently spread to relieve the saw from the friction which would otherwise be exerted upon it.

There is no doubt about Mr. Doncaster being the original inventor of this device. But as he never applied for a patent upon it, when the Crosby patent expired, and other manufacturers commenced the manufacture of resawing-machines, this same device, with various modifications, was generally adopted; and up to 1869 nearly every manufacturer of wood-working machinery included in his catalogue a resawing-machine.

In this year a cloud appeared, which threatened for a time a general raid upon both the manufacturers and users throughout the whole country. It appeared that, years before the original Crosby patent had expired, Messrs. Myers & Unison had jointly taken out a patent for alleged improvements in resawing-machines in which (*à la* Stover) they had claimed, not only what *they* had invented, but everybody else. Their claims covered the spreaders referred to; also the use of wide collars and adjustable guides; and, in fact, everything which went to make up a resawing-machine.

This patent, originally granted for fourteen years, had run the allotted time and been extended for seven years longer; and just before the seven years expired, Mr. Unison took his grip-sack and started out for a general raid, threatening both manufacturers and users with immediate suits and injunctions, provided they did not make immediate settlement with him for infringing a patent that had never been advertised or in any manner put upon the market, or any steps taken to notify the public of its existence. Some were frightened into a settlement, while others told him to go ahead. There was only one suit commenced, and that was against the Messrs. Hawley, an extensive lumber firm in Albany, N. Y., in connection with Mr. Doncaster. The Messrs. Hawley were using a number of machines of Mr. Doncaster's make. They, to use a slang phrase, "did not scare worth a cent," but went at it in earnest.

The result of the litigation was that Mr. Unison was not only defeated in the Circuit Court of the United States, but his patent was set aside as null and void. Other raids were made about this and subsequent years, which will be referred to hereafter.

CHAPTER VIII.

ABUSES OF PATENT-LAWS—THE ACT OF 1870—*THE WOODBURY PATENT—ATTEMPTS TO BUILD UP ANOTHER PLANING-MILL MONOPOLY—A SUIT IN WHICH THE PATENT WAS SET ASIDE.*

IT is not our purpose at this time to discuss the advantages or the disadvantages under which the public have labored from time to time in consequence of perverted patent-law, or the alleged patented inventions which have grown out of it. There is no question but the original intent of the patent-law and the institution of the Patent Office was to protect the honest, *bona fide* inventor in the works of his brain. But a good law perverted by designing men may become an unjust one, and work injury not only to the individual inventor, but the public also. It may be almost impossible to so frame a law that its provisions may not be evaded or taken advantage of by selfish and designing men for their own purposes, thereby working injustice to an honest and unsuspecting public; and it does not require a very profound lawyer to discover this fact in many cases.

The act of July 8, 1870, sec. 24, was intended to correct certain faults which had existed under the former laws, and to enable an honest, *bona fide* inventor, whose application may have been rejected through the ignorance of the examiner, or otherwise, to obtain another hearing, and again present his claims for a further consideration before the Patent Office. The section referred to reads as follows:

"And be it further enacted, That any person who has invented or discovered any new and useful art, machine, manufacture, or composition of matter, or any new and useful improvement thereof not known or used by others in this country, or not patented or described in any printed publication in this or any foreign country before his invention or discovery thereof, and not in public use or on sale for more than two years prior to his application, unless the same is proved to have been abandoned, may, upon payment of the duty required by law, and other due proceedings had, obtain a patent therefor."

While the provisions in this act were intended to relieve a certain class of inventors who had failed to obtain their just claims, the same act was taken advantage of by others whose inventions were not original, and for that reason were justly refused, and had long since been abandoned to the public with their full knowledge and tacit consent. Many of these old claims were revived and, by the assistance of skilled attorneys, pushed through without any regard to the welfare of the public. Conspicuous among this class of pretended inventors was Joseph P. Woodbury, with his alleged invention of the pressure-bar, which is used upon all planing-machines, and had been in public use for more than twenty years; and the manufacturers and users were more than astonished when it was announced that a patent had been granted to him dated April 29, 1873.

At first the planing-mill men looked upon it as a huge joke, as it became known that this same Joseph P. Woodbury had, on the 3d day of June, 1848, made application for a patent on this same device, and, after a close examination, it was rejected upon the grounds that the same device was shown on a machine patented several years previous, and consequently he was not the original inventor; and, further, he had withdrawn the application and the Government had refunded a certain portion of the fee, as provided by law in cases of rejection and abandonment.

No further notice was taken of it until it was announced by circulars received that the patent had been assigned to a certain company of capitalists under the title of "The Woodbury Patent Planing-machine Company, of Boston, Mass.," with a capital of several million dollars, and that they were about to adopt certain measures for enforcing their claims.

Those circulars set forth—which were sent to all users and owners of planing-machines—that the following royalties upon all lumber planed or dressed from the date of the aforesaid patent, and in future, would be as follows: "Twenty cents per thousand feet of boards, plank, or timber (board measure estimated at one inch thick or less) planed, dressed, manufactured, tongued, grooved, sided, or straightened upon the machine or machines upon which said invention and improvement is hereby licensed to be used; twenty cents for each and every thousand of clapboards planed by the use of such machine having said improvement licensed as aforesaid (estimated at four feet long, or *pro rata* for all over four feet long); and twenty cents for each and every thousand lineal feet of gutters, conductors, mouldings, or any other irregular forms of lumber planed or cut with any machine on which said improvement may be used under this license;—payable in quarterly payments on the first days of February, May, August, and November of each and every year hereafter."

Notice accompanying this document was to also notify all that if this form of license was not signed at once, and its provisions complied with, suits for infringement would be commenced without further notice.

Finding this company were in earnest, and that an attempt would be made to enforce the claims of that patent, circulars were prepared and sent out among the wood-workers, inviting them to meet with the manufacturers, and all other parties interested, at Albany, N. Y., to take into consideration the proper means for their own protection. It was unanimously resolved to form themselves into an association, raise the necessary funds, and employ the best counsel to defend any actions that might be brought against any member of the association. John T. Drew, an eminent patent-attorney, was retained with instructions accordingly.

Nothing, however, was done by the company except to annoy the planing-mill users with threatening letters and circulars until May 4, 1875, when a petition was filed with the Attorney-general of the United States, by Mr. Lyman Gould, of Norwich, Conn., for a *scire facias* proceeding to set the patent aside. This was done in order to arrive at some decision, and relieve the planing-mill owners from being constantly annoyed by threatening letters and circulars from the Woodbury company.

The ground upon which this petition was made, as set forth in the petition, was that he had proposed to them, through his attorney, Mr. Drew, that they should commence a suit against him or any other party which they might select, and thereby test the validity of the patent, and stop the annoyance to his customers and others by constantly threatening them with a multiplicity of visits. Another reason set forth in the petition was, that many of the witnesses were old men and feeble, and that, by constant and prolonged delay, their death might be the means of their testimony being lost; that he believed the patent was obtained by fraudulent representations at the Patent Office; and that the device covered by the said patent was in common use and on sale, with the knowledge and consent of the patentee, for more than two years prior to his application for a patent in 1848; and that the said Joseph P. Woodbury was engaged in selling, as the agent for another firm, machines, with pressure-bars attached, as early as the 28th of March, 1846.

While the investigation which followed did not show any direct fraud on the part of the Patent Office, it brought out the fact that the patent had been rejected on the same grounds as before—for the lack of novelty, and that M. D. Leggett, the Commissioner of Patents, had finally issued it under protest, and in opposition to the judgment of the board of examiners in chief, but in accordance with a decision of the Supreme Court of the District of Columbia in the *ex parte* case of Gray. The owners of the Woodbury patent appeared, by their counsel, in opposition to this petition, and, by bringing in a mass of testimony and promising to bring suit at an early day in order to test its validity, the order for *scire facias* proceedings was countermanded.

The next move in this interesting game was a circular sent out by the Woodbury Patent Planing-machine Company, indorsed by Mr. John T. Drew and some of the prominent members of the Planing-mill Association, recommending a compromise by each paying one hundred and sixty dollars per year royalty for each machine, in lieu of the former schedule of prices; also requiring each one so licensed on these terms to sign an agreement recognizing the validity of the Woodbury patent, and that they would in no way aid or assist, in any manner whatever, in the defence of any suit that might be brought against those who might refuse to take out a license under this patent. Some were inclined to comply with those terms, and paid the royalty demanded and obtained a license.

In this arrangement the manufacturers were left out, and no provision made for them; and as there was a strong suspicion of treachery somewhere, a meeting of the manufacturers was called at the St. Nicholas Hotel, in New York, to discuss the situation and devise means for their own protection. The result was that they formed themselves into an association under the name of "The Planing and Moulding Machine Manufacturers' Association;" elected their officers, with authority to employ counsel to defend any suits which might be entered against them or their customers. Each manufacturer notified his customers to make no compromise with the Woodbury company; and that if any suits were entered against them, they would be defended by this association.

This effectually put a stop to the compromise measures, and there was no other resort for the Woodbury company but to commence suit or abandon their claims.

The object of the manufacturers in forming this association was of a twofold nature. One was the desire to protect their customers who had purchased their machines in good faith; and another was that, if the Woodbury company succeeded in sustaining the patent without any provision for the manufacturers, when this object was accomplished it was suspected that it was their intention to start a large manufactory of their own, and refuse to license any one to manufacture and sell under their patent; thereby creating another monopoly greater than that of the Woodworth.

Mr. Lyman Gould, who was elected president of the association, was authorized to retain counsel and appear on the part of the association as the defendant, in case a suit was brought, the expenses to be assessed upon the members and such other interested parties who might wish to unite with them.

The Woodbury company, finding there was no other recourse, finally entered suit against one Allen W. Keith, of Malden, Mass., for infringement of the aforesaid patent. The bill of complaint set forth their grievances in the usual manner, and was filed in the Circuit Court of the United States for the District of Massachusetts, on the eleventh day of December, 1875. Messrs. D. Hall Rice, Benjamin F. Thurton, and Charles E. Pratt were retained as counsel for the defence, and filed the answer for Mr. Keith in the usual manner, setting forth the grounds for the defence, and also filed it with the court on the seventh day of February, 1876.

The suit was vigorously contested on both sides; and a vast amount of testimony was produced by the defence showing conclusively, first, that Woodbury was not the first and original inventor of the pressure-bar; and, second, that if he was, he had clearly abandoned it after its rejection in 1848, and allowed it to go into public use and on sale with his full knowledge and consent for more than twenty years.

These facts were so clearly set forth by testimony and exhibits on the part of the defence that the patent was declared void and set aside by the Circuit Court. The Woodbury company, not satisfied with this decision, appealed to the Supreme Court of the United States, which, after reviewing the testimony, confirmed the decision of the Circuit Court, thus putting an end to one of the greatest frauds that was ever attempted upon the public.

There were in use at that time twenty thousand machines that would have been liable to a tax under the offered compromise of one hundred and sixty dollars per year, which, if they had succeeded, would have taken from one of the prominent industries of the country the sum of *three million two hundred thousand dollars* annually for seventeen years, provided no more mills had started; making, in the aggregate, the sum of *fifty-four million four hundred thousand dollars* that would have been wrung from the industries of the country to enrich half a dozen greedy cormorants, without any compensation in return whatever.

If Joseph P. Woodbury had been the first and original inventor of the pressure-bar,—which it was plainly proved that he was not,—and had given the public this really valuable and useful device, there is no reason why he should have been deprived of a reasonable compensation for his labor and expenses; but even if he was, there would be a manifest injustice in awarding any such sum as was demanded by the company who attempted unjustly to enforce his claims.

Since the time referred to, the manufacturers of planing-machines have increased. Many valuable improvements have been added, until the planing-machine of to-day, for perfection in its construction and the quantity and quality of its work, ranks second to no other class of labor-saving machinery; and by the use of special tools and improved machinery for their construction, and with no royalties to pay to greedy corporations, the manufacturers are enabled to put this valuable and useful machine in the market at a price within the reach of lumbermen of moderate means. The introduction of cast-steel cylinders renders them strong and safe, and enables them to be run at a much higher rate of speed than formerly, and with a faster feed—thus increasing their capacity and usefulness.

We have now traced the planing-machine from its earliest inception down through its various stages of improvement to the present modern-made machine; and to pursue this subject further would be uninteresting to planing-mill men, who are supposed to be familiar with most of the machines of the present time, But we cannot close this history without indulging in a few reflections upon modern improvements and the inventive genius which naturally suggest themselves.

The object and ambition of the original inventor of any machine—who sometimes spends many valuable years of his life in the development of his idea—is to produce a certain result; when that result is accomplished and looked upon by another inventor, it appears to him exceedingly simple.

The object sought by the first inventor of the planing-machine was to devise certain means whereby boards could be planed by machinery. Little attention was given to the style, beauty, or symmetry of its parts. A strong wooden frame was the first thing required; and then to adapt certain devices to that frame to perform the work was the next consideration. No matter if the cylinder was composed of three triangular pieces of wrought-iron fastened to a bar of iron for a shaft, with nothing to support the knives between them but their own strength, it demonstrated the principle and established the fact that lumber could thus be planed by the action of rotary cutters.

Inventors had exhausted their skill for years in endeavoring to invent some means of planing lumber other than by the slow and laborious process with the hand-plane. But in all their efforts they seem to have never departed from the idea of the reciprocating motion of the hand-plane. Their machines were not successful in accomplishing the object sought for; and it would seem that rotary cutters running at a high speed were only resorted to after every other device had failed. In the first attempts to apply the rotary cutter-head, the lumber was pushed through by hand; but this was found to be not only a laborious operation, but a dangerous one. With the imperfect devices for holding down the stuff while being acted upon by the cutters, the knives were liable at any time to catch the stuff and throw it back towards the operator with great force. In fact, it was very soon discovered that some automatic feeding-device must be adopted in order to render the machines safe, effective, and practical; and the introduction of rolls for this purpose was the first thing that presented itself. Although they were nothing but blocks of wood with iron gudgeons, and turned round by a wooden pulley attached to the gudgeon for driving them, yet it established a principle and demonstrated the fact that lumber could thus be automatically fed through the machine while the surface was being acted upon by the cutters.

And so on with every other part of the machine. One idea suggested another, and improvements were made from time to time as their necessities presented themselves.

Although Mr. Woodworth has the credit of inventing the planing-machine,—which still bears his name,—much had been done towards it by other inventors previous to his time; but to him, no doubt, belongs the credit of collecting the various abandoned experiments of other inventors which had preceded him, and so combining, modifying, and arranging them with his own ideas as to make a successful and practical machine.

This is the history of all new and useful inventions; and it may be truly said that it is doubtful if there is one of the many useful machines of the present day, either for working wood or iron, that is purely the invention of any one man. An inventor, for instance, discovers the necessity for a machine to facilitate the manufacture of a certain article ; he devotes his time and energies to discover the necessary combination of mechanical devices which will imitate substantially the same motions of the hand in performing the same work. After a time, by hard study and close application, he succeeds in bringing together the necessary mechanical devices to produce those motions, and the work which had heretofore been performed by hand can now be successfully performed by the machine—just as perfect and a great deal faster.

But after all, certain defects may be discovered that were not anticipated by the inventor at that time, which he or a subsequent inventor may remedy, and thereby render the machine much more simple and effective. A third inventor, after examining and studying what the first and second have done, will also discover certain defects and chances for improvements, which the first and second inventors never thought of. And so it goes on from one to another, just as the planing-mill of the present day was evolved from Mr. Woodworth's first machine.

The sewing-machine is another practical illustration of progressive mechanical invention. The first sewing-machines exhibited at the World's Fair in New York were crude affairs as compared with those at the present time. And although Mr. I. M. Singer and others had devoted years of study to construct a machine which would stitch a plain seam, it was only a partial success until another inventor, Mr. Elias Howe, Jr., came forward with a needle having an eye near the point, which enabled them to accomplish that object which had been so long sought for. The original machines, as exhibited at the time and place just referred to, were run by a crank with the right hand, while the work was guided by the left, and an expert operator could make about one hundred stitches per minute. This was considered lightning speed as compared with hand-sewing, and excited the wonder and admiration of the immense crowd of spectators which gathered around them daily to watch their operation. Nothing but plain stitching was then attempted. Now, when we compare those machines with the machines of the present day, with all their attachments of hemmers, tuckers, rufflers, quilters, braiders, and the Lord knows what else, together with the lightning speed at which they are run, we may truly exclaim, "Great is the progressive inventive genius of the present age!" If our girls, with all the stitching, flouncing, and puckering that is put upon their dresses, were obliged to perform all this work by hand, as their grandmothers did, they would pray for the fashions to change and give them their grandmothers' simplicity of dress.

The mowing-machine and reaper are also illustrations of this subject. While McCormick had expended thousands of dollars and years of time in his attempts to perfect this machine, it was only a partial success until Hussey invented the finger-bar, which proved to be the connecting-link between it and success. And although Mr. Hussey had a hard struggle to sustain and protect his rights against money and powerful influence, he was one of a few original inventors who were successful in sustaining their rights. His death occurred in a railroad accident between Baltimore and Washington, while the suit with McCormick was pending at the latter place; yet his friends carried on the suit to a successful termination, and his widow realized a large fortune from it.

It is characteristic of the American people that, if one man invents anything new and useful, another will make an effort to invent something better. After years of untiring labor, when Prof. S. F. B. Morse had succeeded in establishing the fact of telegraphy, other inventors came forward to share the honors and divide the profits with him; but after many a hard-fought battle, the Morse system prevailed over its competitors.

But even now that system has found a rival of no mean proportions, in the telephone. This system, of transmitting the human voice to a distance is still in its infancy, and only the "iron-clad patent" of Prof. Bell prevents other and better systems from being introduced.

Inventive genius, however, is at work; and when the Bell patent expires, there is no doubt but more perfect and delicate instruments will be put in use, so that messages may be transmitted by telephone as far as by telegraph. And when that time arrives, the telegraph, like the stage-coach and the canal-packet as compared with railroads, will be obliged to give way to its more rapid rival.

Truly we live in a fast age!

The following chapters are devoted to the construction, care, and management of planing-mill machinery.

CHAPTER IX.

CONSTRUCTION OF MACHINERY—QUALITY AND STRENGTH OF CASTINGS—CARE IN MOULDING—FRAMES FOR MACHINES, ETC.

THE important purposes to which iron is applied in the construction of machinery render it always a subject of interest to the scientific mechanic; and there is no time in its history, from its first discovery to the present time, when its importance and the necessity for its use is more appreciated. There is scarcely anything connected with the mechanic arts at the present time but what iron, either cast or malleable, enters into its composition directly or indirectly.

Castings for machinery should never have less tenacity than sixteen thousand pounds to the square inch; and the safest plan, when machinery is to be constructed requiring great strength, is to require tests to be made of certain mixtures of iron, and specify in the contract that the castings shall show a certain strength. And then leave it to the foundryman to select his own grades of iron, and mix them according to his own fancy. Poor iron in castings is bad enough at all times; but even with good iron the machinist often has other troubles to contend with.

Patterns may be carefully made according to the drawings, and all necessary allowances made for shrinkage, planing, turning, etc.; but if the moulder is careless with his work, the casting may come out crooked and winding, so that it will require double the work in finishing. Sometimes it may happen that the faults are so great that the casting cannot be used ; and then the labor of moulding, casting, and remelting is a loss to the foundry.

Another difficulty machinists have to contend with, in castings that require to be finished upon the surface, is large holes just below the surface. These holes are frequently so well concealed by the outer surface that they are not discovered until nearly the whole surface of a large piece is planed off. If not too large, they are sometimes filled up with other metal ; but if they are large enough to materially weaken that part of the machine, they must be returned to the foundry. In this case, the foundry loses the casting, and the machine-shop the labor of planing.

In most cases these faults may be avoided by reasonable care on the part of the moulder. These spots, or, as they are generally called, *blow-holes*, are caused by the pent-up gases that are generated by the melted iron coming in contact with the sand. The sand being damp, and containing more or less vegetable matter, generates a large amount of gas and steam ; and if some provision is not made for its escape through the sand, the upper surface of the casting will be filled with those air bubbles that cannot escape. This may be avoided if proper care and attention is exercised on the part of the moulder in giving the mould sufficient vent. This is accomplished by running a small wire through the sand in the cope before the pattern is withdrawn, so as to form a series of small holes—not large enough to allow the iron to run through, but sufficient to allow the gases to escape as the iron rises in the mould.

In heavy castings, to insure success it is not only necessary to perforate the sand in the manner just described, but also to use what moulders call *risers*. A riser is a round piece of wood, varying in size and length according to the size of the casting. This piece of wood is placed in the sand, one end resting upon the pattern, and the other projecting above the flask, so that when the flask is filled with sand and rammed up, the riser may be withdrawn, leaving an opening from the mould to the surface of the sand. The iron rises in this hole when the mould is filled, and not only allows the gases to escape, with other lighter matter which may float upon the surface, but also exerts a pressure upon the iron while in a liquid state, in the same manner that a column of water exerts a pressure upon a pipe; and castings thus made, under a moderate pressure are more compact and of finer grain.

Good castings, when taken from the sand and brushed off, should have on the outer surface a smooth, clear, and continuous skin, with regular faces and sharp angles; and when broken, the surface of the fracture should be of a bright bluish-gray color, of close-grained texture, and uniform, except that the portion near the surface may be somewhat brighter, and the grain closer. A mottled appearance upon the face of the fracture is an indication of a poor casting, that will be deficient in strength from the lack of uniformity of the iron.

In designing patterns for castings, great care and judgment should be exercised in giving each part, as near as possible, an equal distribution of iron. There should be no abrupt variations in the thickness ; for if one part is thinner than another in the same piece, and cools before the other, the shrinkage of the thinner part will have a tendency to draw the heavier part, that may still be in a semi-liquid state, out of its place, and the casting will either be distorted, or the thinner portion separated from it. A pulley, for instance, with light arms and a very heavy rim and hub, will be very likely to separate from the arms in cooling, or draw the rim out of a true circle opposite to each arm ; and if not entirely separated, there will be so much strain upon them that the slightest blow will cause them to separate from the rim or hub. And whenever this happens, there will always be an open space between the two surfaces of the fracture. This may be avoided by artificial cooling of the hub, or by making the arms curved, so that the strain by unequal shrinkage will only straighten the arm somewhat, instead of tearing them asunder.

Whenever it becomes necessary to construct patterns with a thick and thin portion in close proximity to each other, it is better, if the nature of the work will admit, to give to one portion or the other a slight curve. The frames for machinery that are cast in one piece with the various sections joined together should have all the lighter portions connected with it made, if possible, in curves; otherwise, some portions will be either warped or the lighter portions parted from the heavier by unequal shrinkage.

It frequently becomes necessary to construct patterns for machinery of such shape that, if the pattern itself was the exact counterpart of the casting required, it could not be withdrawn from the sand. In this case, resort must be had to cores. The pattern-maker attaches a plain block to the pattern, to indicate to the moulder the exact spot where the core is to be set. He then constructs a core-box of a shape to meet the requirements of the casting. In this box the moulder makes his core, which is composed of coarse sand, mixed with flour or some other substance, such as molasses or sour beer, which is added in order to give it sufficient strength after being dried in the oven to handle without danger from crumbling. This core is then placed in the mould in the exact position indicated by the block or print, so that, when the iron runs around, it forms the shape required in the casting.

Carelessness in setting cores, on the part of the moulder, is another one of the troubles which the machinist has to contend with. If a hub is to be bored to a certain size, and the pattern-maker has made ample allowance for that purpose, if the moulder is careless in setting the core, so that it is not central with the hub, the machinist often finds it a difficult matter to bore it out to the size indicated on his drawings.

All these mistakes—which should be avoided—enter into and add to the net cost of the machine, which falls, in most cases, upon the proprietors; and if every employee would consult the interests of his employer, much needless expense might be avoided.

As many of the castings used in planing-mill machinery require to be made with cores, the hints given in the foregoing pages on this subject, as well as castings generally, are applicable to this class of work; for probably there is no class of machinery that is subjected to greater strain and the same wear and tear as that. When we speak of planing-mill machinery, we include all that class of machines used for wood-working; as the conditions under which they all work are substantially the same.

The planing-machine, being the largest and heaviest machine in the outfit, and required to perform the heaviest work, should be made of sufficient weight and possess strength in all its parts in proportion to the labor which each part has to perform. The frame, which is now made of iron by all first-class manufacturers, should be strong and of sufficient weight to give it solidity and support the working-parts without any vibration; but the most important parts of a first-class planing-machine are those parts which perform the work. There is no economy in putting a large amount of superfluous iron in the frame, and making the other parts light—especially those which perform the most work and are often subjected to the greatest strain.

A machine of this kind may weigh sixty-five or seventy hundred pounds, and yet not be any stronger or able to perform as much heavy work as one that might weigh five or ten hundred pounds less. Such a machine, while having much less iron in the frame, may have in its working parts one third more strength.

The correct principle in the construction of planing-mill machinery is to so apportion the several parts as to get the greatest amount of strength from a given amount of material.

The custom of purchasers inquiring of the manufacturers the weight of their machines, and then comparing their prices with the gross weight, is a bad one, and often leads to disappointment and unsatisfactory results. This practice has led some makers to put an unnecessary amonnt of iron in their frames, so as to give the impression that, because their machines are heavy, they possess superior qualities over another, who may claim less weight; when the real facts in the case are, the lighter machines may be much the strongest and durable.

The cost of a planing-machine is not all in the frame; and a few hundred pounds of iron either way makes but little difference. The working-parts is where the cost comes in, and the heavier they are and the more accurately they are fitted up, the more they cost whether the frame is heavy or light.

The feed-works, next to the cylinder and side-cutters, is the most important part of the machine, and one that is in many machines very deficient. How often do we find planing-machines with the cylinder and side-cutters fitted up in good shape and capable of performing good, fair work, but spoiled by having only one pair of feed-rolls, three or four inches in diameter,—and the top one fluted at that,—and held down by rubber springs or some other worthless device, with scarcely power enough to surface a three-eighth panel. Yet such machines are expected to carry a two-inch plank two feet wide through the machine, and take off a heavy cut; and, if the feed will not do it, it is expected that the operator will make up the deficiency with his abdomen. We have a poor opinion of that style of machine. Yet many will purchase them because they are *cheap*; but the fact is, such machines are dearest in the end.

A planing-machine, to give a good and reliable feed, should have not less than three pair of feed-rolls, from six to eight inches in diameter, and connected by some good system of expansion-gears, and weighted so as to give a uniform pressure whether the lumber be thick or thin. Two pair should be placed in front of the cylinder, as more friction surface is required to feed the lumber in than to feed it out; especially when the lumber is damp and frosty. But after it has passed under the cylinder, and one side is planned, one pair of feed-rolls, if properly weighted, is amply sufficient to carry it out..

We abominate fluted rolls, and they never should be used on a machine that is expected to do good, smooth work. Smooth rolls, if of proper size and sufficiently weighted, will always give a reliable feed, and one strong enough to carry anything through the machine that is fit to go through it. While fluted rolls with the same pressure may give a stronger feed, the trouble with them is that, if the lumber is soft or damp, the projecting points of a fluted roll press into the lumber, bending the grain to a depth just in proportion to the weight that is brought to bear upon it, and, before those indentations have time to come back again to the surface, it is planed over, leaving the grain in that position; and, in a few days, or sometimes in a few hours, when exposed to the air, rises again to its former position, and shows upon the surface a series of corrugations corresponding to each flute in the roller.

For this reason, no machine, no matter how perfect it may be in all its other parts, can do smooth work under these conditions.

The cylinder should be large enough in diameter to give a fair width of knife and clear the bolt-heads, without having too much *scrape*. Manufacturers within the last thirty years have gone from one extreme to another in the size of their cylinders. The old Lester machines, that were in use thirty years ago, are no doubt well remembered by some of the old planing-mill men. The cylinders were of gun-metal, in some cases as large as fourteen inches in diameter, and were skeleton-shaped, or what was then known as the "open cylinder," usually having three knives hung inside of the wings, and fastened by counter-sunk headed bolts, with nuts screwed upon the face of the knife.

These old-timers required an immense power to run them, and, at a feed of about thirty to forty lineal feet per minute, they turned out very good work; but the *music* of those old machines could be heard for a mile around.

The solid iron cylinder was afterwards introduced, and came into general use, not only on account of its being cheaper, but it proved to be much better, and could be made smaller in diameter, and run with much less power and greater speed. Some manufacturers went to the other extreme, by making their cylinders just as much too small as the old ones were too large, and just as much out of proportion.

CHAPTER X.

CARE REQUIRED IN THE CONSTRUCTION OF WOOD-WORKING TOOLS—BEST PROPORTION FOR THE CYLINDER—RELATIVE LENGTH AND SIZE OF JOURNALS—CAST-STEEL CYLINDERS—THE BEST PRACTICAL METHOD OF FITTING THEM UP, ETC.

THERE is no piece of machinery pertaining to the business of wood-working that requires more care in its construction than the planing and matching machine. The speed is so rapid with the principal working-parts that any little imperfection will soon manifest itself. A steam-engine, or almost any other slow-running machine, may have slight imperfections, which may not manifest themselves for months after they have been put in use; but let one of the journals of a planing-machine cylinder not be perfectly round or be slightly sprung or a pulley or cutter head not in perfect balance, and you will find it out in less than ten minutes after the machine is started.

Again, wood-working tools—especially the planing-machine—do not always go into the hands of experienced mechanics. An iron-turning lathe, planer, or upright drilling-machine, when put up in the machine-shop, goes into the hands of a competent machinist—one who is not only competent to put it up and run it, but, in most cases, with the suitable tools and patterns for that purpose, able to construct it and put it together; and if there should happen to be a slight imperfection in the work which has escaped the notice of the workmen at the factory where it was fitted up, he will quickly discover the cause and correct it.

But not so with a large majority of the planing-machines that are sent out from the different manufactories. A few, it is true, go into the hands of men who thoroughly understand their business; and if a machine is properly put up and adjusted at the factory, there never will be any trouble in putting it in successful operation. But a large portion of the planers which are sent out from the different manufacturers go into the hands of inexperienced operators, who are not practical mechanics, and whose experience with machinery is very limited. And as a general rule the machine is belted up, and started just as it came from the factory; and if everything happens to be in perfect adjustment, and is level and out of wind, it may go off all right. But if there should be any little imperfection in the fitting or adjustment, it is not usually discovered until something begins to smoke, and then perhaps the difficulty, whatever it may be, is not remedied until the machine is seriously damaged.

The rapid motion of a planer is such that, in order to avoid vibration, it requires that the frame be not only solid, but well put together. And here is a point where the skill and judgment of the designer are brought into requisition. It is not always the case that the frame having the greatest number of pounds of metal is the strongest and most efficient in resisting vibrations. Frames are frequently met with, the plates of which may be an inch thick, surrounded by a flat moulding. Such frames, although they contain an abundance of metal, are not well calculated to resist lateral vibration; for it must be understood that, with a combined planer and matcher, the tendency for vibrating sidewise is as great as perpendicular. Therefore, if the same frame, instead of its plate being one inch thick, it were just one half of that thickness, and the other half were put into wide, heavy ribs, with the same quantity of metal, double the strength to resist vibrations would be obtained.

The double plate frame which has recently been adopted by many first-class firms, if properly proportioned, and the plates far enough apart to give sufficient depth, is probably one of the strongest frames that can be made from the same amount of metal. But to answer well the purpose designed, the space between the plates, for heavy machines, should not be less than two inches.

The plates in this style of frame may be quite thin, and yet very strong and substantial. Whatever style of frame may be adopted, it should be put together with planed joints; and the top, wherever any of the works are attached, should be planed square and straight and lengthwise, so that when it is set up and bolted together the top of both sides of the frame will be square and parallel with each other. Then the whole frame should be levelled up both crosswise and lengthwise before any of the other parts are attached; and when thus set up, it should never be moved or changed until the machine is completed. The bed-plate for the top cylinder should next be put on and bolted to the frame; and if it has been carefully and accurately planed, it should agree with the frame and be perfectly level both ways. The back shaft should then be fitted into its boxes by the same level, and squared from a line previously drawn through the bed and square with the frame. From these two points all other parts of the machine should be put up and squared and levelled.

The advantages of erecting a machine in this manner, and always working from these two points, are that if every part is thus put up with reference to these two points, when the machine is finished and shipped to its destination and set up, if carefully levelled from these two points, every other part of the machine will be true and out of wind. Frequent cases have occurred where machines have been set up without reference to these two points, but levelled anywhere on the frame, that have given a great deal of trouble by heating the roller-boxes, binding so as to cut and get stuck fast, and many other troubles, before the real cause was discovered, and the manufacturer it often blamed for the ignorance of the operator; whereas, if proper instructions had been given, and those instructions carried out, the machine would have started off all right in the first instance.

In all modern machines the bearings are all much longer than formerly. The cylinder-boxes, instead of from four to six inches, are now made from ten to twelve inches long; and when bearings of that length are babbited and scraped down to a perfect fit and sufficient packing put between the box and cap, the caps may be screwed down tight, and yet the cylinder will be perfectly free to revolve. But just raise one foot of the frame sufficient to put a piece of thin pasteboard under it, and it will cause the cylinder-boxes to so bind that it will be impossible to turn it with the hand without loosening up the caps and adding more packing. And if the machine were run in that condition, it will be found that the shaft does not bear upon the whole surface of the box, but only upon a small portion of it; and the consequence is, it will heat, and continue to heat, until it wears down again to a perfect bearing.

This accounts for the tendency of all new machines to heat when first started. It is almost impossible to place the machine exactly in the same position that it was when first set up in the shop; but if especial care is manifested in levelling across the bed-plate and through the boxes of the back shaft, that point may be found so near that a machine will frequently start up without any inconvenience from heating.

For a planer weighing 8000 pounds the frame should not be less than from 11 to 12 feet long over all. The cylinder should not be less than 7 inches in diameter at the extreme points; it should be four-sided, and provided with slots planed on all four sides, and of sufficient width and depth to admit of a $\frac{5}{8}$ bolt, with a head $1\frac{1}{8}$ inches square and $\frac{3}{8}$ thick, for holding the knives. The thickness of metal from the face of the cylinder to the slot should be $\frac{7}{16}$ inch. The reason for making this part thicker than the head of the bolt, is that in case of accident, when something *must* break, it is better for the bolt-head to give way than to tear a piece out of the face of the cylinder, as is sometimes the case when the greatest strength was in the bolt-head.

The cylinder being the most important part of the machine, and as the forged cast-steel cylinder has now come into general use, the hints given for the fitting up of cylinders are applicable to that style.

The first step preparatory to fitting up a forged cast-steel cylinder, should be to carefully centre the ends which project from it and form the shaft and journals. After the proper centre is found, and marked with the center-punch, a fine drill should be run in at least one fourth of an inch, so as to prevent the extreme point of the lathe-centre from coming in contact with the steel during the process of turning; otherwise, as the centre in the shaft wears away during this process if allowed to bear upon the extreme point, it would be very apt to work to one side or the other of the true centre and cause the work to run out before it was finished. Besides, the small hole forms a receptacle for oil, and prevents it from cutting the centre.

When the centres are properly prepared, the work should be put in the lathe and tested. If found sufficiently true, and there is surplus stock enough to work to the standard size, it is better to fit it up just as it came from the forge; but if not sufficiently true and the shaft requires to be sprung, never attempt to bend it cold, for two reasons: One is that they are liable to snap off, and the cylinder be spoiled; another is that a cast-steel shaft bent cold is very liable to go back again after being finished, especially should it ever become heated when running. Therefore, the safest way, if the shaft must be sprung before turning, is to heat it carefully and uniformly at the forge until it shows a dull red heat, and spring it in a press for that purpose. If there is no press at hand, it may be put in the lathe on its centres, and, by the use of a bar over the rest, may be sprung in that manner.

When the straightening is completed, never lay it on the ground to cool. Place it upon something in some convenient place so that the air may have free access to it on all sides. Otherwise, if placed so that one side cools faster than the other, that side will in all probability be harder than the other, and every experienced operator of planing-mills knows that, unless the journals of a planing-machine cylinder are perfectly round, they will not run without heating; and when one side of a journal is harder than the other, it is impossible to keep them round. If the machinist succeeds in making them round in the first place, it will only be a question of a very short time when they will not be so. When the cylinder is sufficiently cool to work a cut should be taken over every part of the surface; then, if there should be any imperfections or any part disposed to spring, these defects should be discovered before proceeding to finish it.

The journals, or that part of the shaft which forms them, should be left large enough to admit of another turning in order to finish it after the planing is completed. When ready for the planer, it should be put upon its centres, and, by means of templets, every part should be reduced to the same uniform size and shape, in order to secure a correct running-balance when finished. When taken back to the lathe after the planing is completed, the points should be carefully tested with a tool to ascertain whether any part has become sprung during this process. If so, never attempt to spring it back, but, with a pointed scraper, scrape out from the opposite side of the centre so as to draw it sufficiently to cause every point of the cylinder to touch the tool alike when it is turned carefully around with the hand.

Now, with a sharp, well-tempered tool, the bearings may be turned for the pulleys, and lastly, by a series of light, fine cuts, the journals may be finished to the standard size. If the last cut is very light, and the point of the tool the proper shape, it may be finished without the use of a file; for the least filing that is done, the better. But if a file must be used, it should be a very fine one, and used lightly.

When the finishing is completed, it is ready to balance. The balancing-bars should consist of two pieces of steel not over one sixteenth of an inch thick on the edge, and perfectly straight, set into cast-iron blocks, with adjusting-screws attached to the foot of each, so that, when placed upon a planer bed or other suitable platen, they may be adjusted to a perfect level; so that, when the cylinder is placed upon them, the least variation in weight may cause it to roll.

A cylinder or any other body when so placed upon its journals or a mandrel, if in perfect balance will remain at rest in any position it may be placed. If found in perfect balance after being tested upon the bars, it is supposed to be finished; but if not, then it should be placed upon the planer, and a small amount taken off from the heavy side to correct it. But in all cases, whatever is taken off should be from the whole length and upon the centres.

The practice of drilling holes upon the heavy side is abominable, and should never be tolerated. Each bolt and nut should be tested upon a pair of sensitive balancing-scales (which every shop should possess), so that each may be of the same weight, and also that if by any means they should become changed, the balance of the cylinder may not be affected by it. The cylinder pulleys should be turned on the inside as well as the outside, and each carefully balanced afterwards separately; for if either of them should not be in balance, it will affect the working of the machine just as much as if the cylinder itself was out of balance.

Lastly, the knives should be examined and tested. Although each knife composing a set is supposed to be balanced at the factory where they are manufactured, yet it is difficult to find a set that is sufficiently perfect to send out with a high-speeded machine without rebalancing.

This is one of the most difficult operations to contend with unless a machine expressly designed for that purpose is at hand. A set of knives may each show the same weight when placed upon opposite sides of the scales, and still be far from a perfect balance when attached to the cylinder, and run. This is caused by the grinder not being particular enough in preserving a uniform thickness from one end to the other, or in punching the slots not uniform in depth.

Now, if any two knives in a set should happen to have the same defect on opposite ends, while they might show the same weight on the balancing scales, the difference in weight on the opposite ends would make music that would be anything but harmonious to the ears of a careful operator.

In the absence of an instrument for this purpose, the best way to test this fault and correct it is with a single bar. An old knife set in a block of wood answers the purpose very well. Then, with a sharp scratch, draw a line across the back of the knife exactly in the centre, making it deep enough so that it will not slip off when laid across it; then lay the knife across the bar in the manner just described, when any imperfections in this respect may be discovered and remedied by grinding off from the back towards the heavy end. Some depend upon the calipers for testing the width and thickness; but if a knife has the defects just described, the calipers will not correct it.

It may be said that all this care takes time and money, and adds to the expense of the machine. The answer is that, if you intend to send out a perfect-running machine, and one that will give satisfaction and keep up your reputation, you must expect to spend time and money; and if your customers are not willing to pay a fair price that will warrant a good machine, it is better to let them go to some firm that makes a specialty of cheap work, and suffer the consequences.

CHAPTER XI.

SPEEDING WOOD-WORKING MACHINERY — VARIATION OF SPEED IN DIFFERENT MILLS—CENTRIFUGAL FORCE—TENSILE STRENGTH OF BOLTS—PULLEYS, ETC.

MUCH has been written by practical men upon the subject of speed. Cylinders, cutter-heads, steps, boxes, etc., have all been pretty well overhauled; but after all, little has been said upon the subject of the proper speed that should be given them. This subject, as Jack Easy would say, will admit of argument.

Proper speed for all wood-working machinery is of vital importance both to the owner and the operator. It is important to the owner, because machines speeded in a proper manner are enabled to turn out the greatest quantity of first-class work in a given time without unnecessary wear and tear. There is no profit in forcing a machine to earn seventy-five cents more in a day by overspeeding it if the spoiled work and extra cost for repairs amount to ninety. It is also important to the operator to know whether the speed at which his machine is running is beyond the margin of safety, and whether his own life is not constantly in jeopardy in consequence. Again, if a machine is speeded below the average, a sufficient quantity of good work cannot be turned out in a given time to make it profitable;

and in many cases the operator is unjustly blamed in consequence.

It would astonish any one to put a speed-indicator in his vest pocket, and visit a few planing-mills located in different parts of the country, and note the difference in speed among the same class of machines. He would find in about six cases out of ten that the proprietor or his foreman could not tell just what speed their machines were running.

Speed, like everything also, is based upon certain principles and governed by general laws, no matter whether it be the cylinder of a planing or moulding machine, a circular saw, or a pulley. There is always a point which it is neither safe or profitable to go beyond. One man may for a time get twice the amount of work out of a machine that his neighbor does; but if he does it at a large expenditure of wear and tear, he will find in a short time that his machine is used up and incapable of doing good work, while his neighbor's is practically as good as ever.

Now, the only question involved is: Did the first man get enough extra earnings besides repairs in that time out of his machine to enable him to purchase another as good? If not, then he is a loser by the transaction.

We are well aware of the fact that machines that are kept in first-class order, with every part in perfect balance, will stand more speed than those which are not; but as every machine, if run at all, should be kept in order, it is not necessary to discuss the speed of those which are not.

If asked for an opinion as to the best speed at which a planing-machine cylinder should be run that was not in balance I should reply: Do not run it at all—at least until it is balanced.

There is a question of safety involved with all fast-running machinery, as well as profit, to be taken into consideration. No one has the right, either legally or morally, to cause his machinery to be run at a speed that will endanger the lives of his employees, for the sake of extra profit. Implicit reliance cannot be placed in the circulars which are sent out by different manufacturers, as far as speed is concerned. One manufacturer will say that the best and most economical speed for the cylinders of his machine is 3600 revolutions per minute; another will give 4000; while another will put it at 4500; while still another will say that his machine, "owing to its extra strength, etc., will run 5000 revolutions per minute with perfect safety," and he will guarantee it to do first-class work at that speed.

Now, from personal knowledge of each machine, there is no perceptible difference, so far as the cylinders are concerned. They are all about the same diameter, and the shafts and boxes about the same size, and fitted up in the same manner; and each have the same strength, and one runs as smooth as the other, and there is no good reason why one will not stand as much speed as the other.

If 3600 revolutions per minute is the best and most profitable speed for one, 5000 revolutions is altogether too much for the other. The only true way to decide this question is to reduce it to plain figures, which "do not lie," and then let the candid judgment of those who are in favor of "lightning" machines decide whether there is safety or profit in being governed by the circulars of those manufacturers, put forth in that shape for the sole purpose of selling their machines, and who, as long as they can make a sale, and their own lives are not jeopardized, give no further thought of the consequences that might follow.

It is a well-known fact that all bodies revolving around a common fixed centre have a tendency to fly off in a line tangent to that centre, and that force increases in proportion as the square of the velocity. Hence, in all bodies of equal weight, moving in equal circles and at a uniform velocity, the centrifugal force is the same. But all bodies of equal weight in equal circles, but moving with *unequal* velocities, are inversely to each other as the square of their velocities.

In calculating the centrifugal force of a revolving body, the diameter should be taken at the centre of gravity. This is a line through which, if the body were divided upon that line, each part would be of equal weight. With pulleys, fly-wheels, and other regular-shaped bodies of that kind, the centre of gravity usually lies near the outward surface, and is more readily determined than irregular-shaped bodies—such as planing-cylinders and side cutter-heads, etc.

To find the centrifugal force of a revolving body, the following rule is applicable : Multiply the square of the velocity in feet per second by the weight, and divide this product by 32 times the radius in feet at the centre of gravity. This quotient will give the centrifugal force in pounds. Now examine this cylinder, which is 7 inches in diameter, and said to be safe at 5000 revolutions per minute. As the knife is the only weight which will be considered at this time, and is carried upon the outside, it is safe to say that the centre of gravity lies not far from a point taken from the under side of the knife, which would be a circle of 7 inches diamater, or a radius of $3\frac{1}{2}$ inches.

Assume the weight of a 24-inch knife to be 8 pounds. Then, 5000 revolutions would be equal to 152.75 per second, the square of which is equal to 23,332.5; then $23,332.5 \times 8 = 186,660.48 \div 9\frac{1}{3}$ (the product of 32 times the radius in feet) $= 19,999.31$ pounds for the centrifugal strain. As nearly all knives, and this one in particular, are fastened to the cylinder by 6 bolts $\frac{5}{8}$ of an inch in diameter, each bolt would be required to withstand one sixth of the strain, which would be equal to 3333.21 pounds.

The tensile strength of the best Norway iron is 80,000 pounds to the square inch, and a bolt $\frac{5}{8}$ inch in diameter at the bottom of the thread has a sectional area of .24 square inch, the breaking strain of which would be 19,200 pounds; so that if there was nothing but centrifugal strain to contend with, there would be no danger at that speed. But the screwing of them down is an important factor, to be taken into consideration; and here is where the greatest danger lies, especially in the hands of a careless or inexperienced operator. It is quite common to find wrenches used for this purpose with a handle 12 inches long, and sometimes more.

Let us consider the effect that this long-handled instrument may have upon the tensile strength of the bolt. The average bolt, as we said before, is five-eighths of an inch in diameter, with a lead of 12 threads to the inch. Therefore, to move the bolt forward $\frac{1}{12}$ inch, it must make one complete revolution, and the handle of the wrench would move through a space of 75 inches; and, by the rule for calculating the power of a screw, the proportion would be as $\frac{1}{12}$ to 75. And if the operator exerted a strain, upon the extreme end of the handle, of 25 pounds, then the proportion would be thus: $\frac{1}{12}$: 75 :: 25 : 22,500 pounds. Now, add to this the 3333.21 pounds of centrifugal force, and the result is 3333.21 + 22,500 = 25,833.21 pounds.

Now, by comparing this with the tensile strength of the bolt (19,200 pounds), the result is 6633.21 pounds beyond the tensile strength of the bolt. But friction, which is generally considered as the enemy of all mechanical movements, here comes in as a friendly element. The friction upon two similar surfaces within the point of abrasion is .25 of the weight which is pressing them together up to that point. As soon as the point of abrasion is reached, it increases to from .40 to .50 and upwards; and as the marks on the back of the knives immediately under the bolt-heads plainly show that, every time they are screwed down, the point of abrasion is reached, the frictional resistance offered to this long-handled instrument is at least .40 of its power.

Assuming this to be the case, the tensile strain upon the bolt would be reduced from 22,500 pounds to 13,500, which, with the original centrifugal strain of 3333.21 pounds added, the result would be 16,833.21 pounds. This deducted from 19,200 pounds, the ultimate strength of the bolt, would leave a margin of safety of only 2367 pounds, which is much too small to meet all contingencies. And is it any wonder that bolts break and knives fly off on those fast-running machines?

The strain upon the cylinder-bolts and the liability of the knives flying off in over-speeded machines is not the only element of danger. Over-speeded pulleys are just as liable to fly to pieces, and do damage to the machine, as well as the operator. It is not practical to use pulleys on the cylinder shaft of less diameter than 4½ inches, as smaller ones soon destroy the belts and are deficient in friction surface. Neither is it practical or convenient, as the planing-machine is usually constructed, to use pulleys on the back-shaft of a greater diameter than 20 inches; otherwise, the back-shaft would be too high to allow the matcher-belts to run in their proper place.

Now, suppose the pulleys on the back-shaft to be 20 inches in diameter and 4½ inches wide on the face: which would be the right proportion for this purpose, with the average thickness of the rim ⅜ of an inch? This pulley, in order to drive the cylinder 5000 revolutions per minute, would require a speed of 1125 revolutions per minute. Allowing the weight of the rim to be 30 pounds (the weight of the arms and hub not taken into consideration), which is about the average for pulleys of this size, the centrifugal strain, by the rules already given would be as follows: The circumference in feet (5.2375) multiplied by the speed (1125 revolutions), and divided by 60, equals 98.202, the speed in feet per second. The square of this number, multiplied by the weight and divided by 32 times the radius in feet, equals the centrifugal strain; which will be found to equal 10851.79 pounds. The rim of this pulley contains a sectional area of about one square inch, and the tensile strength of the best samples of cast-iron, as determined by Major Wade, of the United States Ordnance Department, is from 15000 to 16000 pounds to the square inch.

It will be remembered, however, that those tests were made upon the basis of cast-iron bars one inch square, and from the best samples, perfectly sound and free from dirt or air-holes; and it is a question whether the average castings obtained from the foundry from day to day will come anywhere near to this standard of strength. But suppose every pulley was perfect and the iron up to the standard of strength: there is, then, only a margin of safety of 3810.40 pounds, which is far below the standard of safety; for no piece of machinery in constant use and submitted to the same constant strain from day to day should be taxed over one half of its ultimate strength. Again, the shape of the material and the manner in which the strain is applied has much to do with it. If the pulley rim, instead of being a flat piece $4\frac{1}{2}$ inches wide and $\frac{3}{8}$ inch thick, were put in the shape of a square bar, which would be about one inch square, it is reasonable to suppose that it would stand a much greater strain than in its present form, and in the manner in which the strain is applied.

The same rule may be applied to this which is applied to beams and girders; and it is unnecessary to state what every one knows—that a cast-iron beam $4\frac{1}{2}$ inches wide and $\frac{3}{8}$ inch thick will sustain more than four times the load when placed edgewise, that it would if placed flatwise. And there is but one conclusion that we can arrive at; and that is, that pulleys of the dimension given are not safe at such high speed.

Aside from the question of safety, there is also a question of economy involved that is worthy of consideration.

CHAPTER XII.

IMPORTANCE OF CARE IN PUTTING UP AND ADJUSTING NEW MACHINES—THE NECESSITY OF EMPLOYING COMPETENT MEN—MISTAKES OFTEN MADE IN SPEED—ANECDOTE—ANNOYANCE FROM BAD BELTS—MATCHER-BELTS REQUIRE EXTRA CARE, ETC.

In a former chapter on the construction of machinery as applied to this class of work, the opinions expressed are the result of over thirty years of practical experience in the manufacture and use of planing-mill machinery.

What we have said of the planing-machine is equally applicable to the moulding-machine, tennoning-machine, sticker, and all other machines used in wood-working. They are all constructed substantially upon the same principle, and may be considered under one head.

No matter how well and perfect a machine may be constructed, if it is not kept in working order, good work cannot be expected from it. It depends a great deal upon the manner in which a machine is set up. Placing a machine in a mill, and belting it up, is not all there is of it. There are certain points about every machine to level from, so as to take the working-parts out of wind. These points should be ascertained and worked from until every part is free to work, before the belts are put on. Many good machines have got a bad name on the start by not being properly set up and adjusted. To a certain extent, the manufacturers themselves are to blame. Whenever a machine is sold, the manufacturer should insist upon having a good competent man on hand to attend to the putting up and starting. Unless the purchaser has a man of experience and ability already in his employ, the manufacturer should send a man from the works even if he is obliged to do it at his own expense.

When a machine, thus started up by a competant man, starts off all right and performs its work in a satisfactory manner for two or three days, there is no reason why it should not continue to do so as long as it is kept in good running order. The reputation of a machine may thus be established so that, if by subsequent neglect the machine does bad work, the manufacturer cannot be held responsible for it.

Competition at the present time is injurious to both the manufacturer and user. In their anxiety to sell, they seem to care but little whose hand it goes into on the start, as long as they can succeed in making a sale, and seldom take the trouble even to inquire whether the purchaser is a practical man himself, or whether he has a man who is. And the result is that many good machines have been condemned and given a bad reputation through the ignorance and incompetancy of the operator; when, if the manufacturer had ascertained these facts beforehand, and insisted upon sending a competant man to take charge of it for a few days, everything would have gone off all right and satisfactorily, and the future operator would have received valuable information, which would have been of use to him for the future management of it. If the purchaser is not in possession of a competent man for this purpose, he should be liberal enough to pay at least the expense of a man from the works to give the necessary instructions ; for in nine cases out of ten, the delay in starting the mill, and the lumber wasted before the inexperienced operator succeeds in getting the machine in working order, will more than pay those expenses—to say nothing about the liability of accidents or damage to the machine.

It is often the case that the foreman of the mill may be a man of unquestionable experience and ability; yet his whole experience has been limited to some one particular style of machine, and, it might be said truly, that what he did not know about that particular make of machine was not worth knowing. But give him a new machine of some other manufacture, and it will require several days for him to become acquainted with all of its peculiarities. Whereas, a man from the factory, who is accustomed to sitting up and testing those machines, would explain to him in a few hours all of those peculiarities.

But it is often the case, especially where a new mill is started, that, while the proprietors may be first-class lumbermen, but with no practical knowledge of machinery, the man who is engaged to take charge of it may be a competent man or he may not. The machinery is purchased and put in the mill, and the manufacturer must take his chances whether his machine will have a fair chance on the start or not ; or whether he will not be compelled in the end to send a man to straighten things out before he can get a settlement for them—not only to put the machine in working order, but perhaps repair damages which it might have sustained through ignorance on the part of the operator, which might have been avoided had a competent man been sent in the first instance.

There is another thing that manufacturers, as a class, are not particular enough about: and that is the speed at which their machines are run. It makes considerable difference, both in quantity and quality of the work, whether the cylinders are run 3000, 3500, of 4000 revolutions per minute. The purchaser is informed that the cylinder should run perhaps 3600; and in order to do so, the speed of the back-shaft must be 900. He goes home and consults with some genius who is a carpenter, blacksmith, machinist, and millwright, all combined. He finds the line-shaft will run *about* so and so, and that a pulley of *about* such a size will be *about* right. A pulley is obtained *about* the size referred to; in his opinion an inch or two either way will not make much difference and is *near enough*. Finally, the machine is started up; it may run 3000, or it may run 4000, and perhaps more or less. However it *hums* and makes considerable noise, and they finally agree that the speed is *about* right; but the work, as far as quantity is concerned, is not satisfactory. The machine is not turning out the quantity of work that it was guaranteed to do; and the manufacturer is either obliged to go himself or send a man to find out what the trouble is, and correct it before a satisfactory settlement can be obtained.

This is no fancy sketch. A case of this kind once came under the observation of the writer. A machine was sold in a neighboring city. The machine was warranted to plane and match fifty lineal feet per minute, and do first-class work, with a cylinder speed of 3600 revolutions per minute. I suggested that a man from the works should be sent to put it up and start it. The purchaser replied that it would not be necessary, as he had a first-class man, who was a competent millwright, to take charge of it, and the speed would be properly attended to.

In a few days after the machine was started, a letter was received, stating that the machine was not working satisfactory, and that there was a miscalculation in the feed, and that only about forty lineal feet per minute could be dressed and make good work. They had tried a larger feed-pulley so as to bring the feed up to fifty feet, but it made rough work and tore up the edges of the board in matching so that they had to abandon its use. I notified them by telegraph that I would be there the next day.

I arrived at their office in due time, which was in one corner of the mill; and as soon as I heard the hum of the cylinders, I was satisfied where the trouble was. I inquired if their machinery was running up to the regular speed; they replied that it was. I informed him if that was the case, unless my ears were greatly at fault, the planer was not running up to its speed by considerable. He replied that the machine was running even faster than I had recommended. His millwright, Mr. A., had calculated the size of the pulley, and Mr. A. never made any mistakes in his figures, and the machine was really running 4200 revolutions per minute, and that I had made a mistake in calculating the feed.

I told him I was not a betting man, but I would agree to purchase cigars for the whole party if, after a close calculation, the speed was over 3200 revolutions; and that Mr. A. should measure the diameter of the several pulleys as soon as they shut down at noon, and, if I was not right, I would make any alterations necessary, at my own expense, or they could ship the machine back at my expense.

They admitted that this was fair enough; and after dinner, Mr. A. brought in a list of the several pulleys, including the band-wheel and speed of the engine. I figured up the speed, and found the cylinders running a trifle less than 3000. I then told Mr. A. that he must lag up that driving-pulley just seven inches, and we would see what effect that would have. Mr. A. demurred a little, saying that he did not believe the machine would stand any such speed, and that it would not be safe to run it. I told him that did not matter, as I would run the machine myself until he was satisfied on that question, but I must have the speed if they required the machine to fulfil the conditions of my guaranty.

Accordingly the pulley was lagged up and the machine started. It ran perfectly steady and turned out the fifty lineal feet per minute, and was perfectly satisfactory to all concerned; and Mr. A. was obliged to admit that at least once in his life he had made a mistake in his figures.

After a planing-machine, or, in fact, any other machine is started up and put in running order, it must not be expected or taken for granted that it will continue so for any length of time unless it is constantly watched and everything kept in perfect adjustment. No class of machinery needs closer watching. With the constant vibrations which this class of machinery is subjected to, bolts and set-screws and nuts will work loose, no matter how well they are fitted; knives and cutters will become dull with use, and require sharpening, balancing, and resetting; belts will become slack and require taking up; the foundation under the machine may settle (especially if none too solid in the first place), and throw the machine out of line, cramp the journals, and cause them to heat; and a hundred other things, too numerous to mention. And only the diligent and watchful care of an experienced operator will detect and remedy these difficulties.

When a machine, especially if it is a heavy one, has run smooth and free for several weeks, and then, without any apparent cause, begins to heat, there is some cause for it; for when a machine has run free for that length of time, there is no good reason why it should not continue to do so for months, provided that proper care is manifested in reducing the packing, and screwing down the caps as the metal lining wears away. But if boxes continue to heat and bind, the probabilities are that the foundation has settled; and it is always best, before attempting to readjust anything, to try the spirit-level upon those points from which the machine was first adjusted, and, if the foundation has settled, it will readily be discovered and remedied at once: for a machine should never be run one hour after it is discovered to be out of line or winding. If the foundation is good, but the shrinkage of the timbers has changed its position with reference to the machine, it is better not to disturb it; but with a few shingles used under the legs of the machine, it can be brought back to its former position.

When this is carefully attended to, the chances are that the machine will go off all right without any further adjustment. But if it should continue to heat, it is evident that there is some other cause, which must be hunted up and remedied, for there is no economy in pouring on oil and running a machine with hot journals. Dirty, gummy oil is frequently the cause. In this case, the cylinder should be taken out, the boxes well cleaned, and the journals wiped off; and after properly adjusting the packing so that the caps may be screwed down solid, the shaft will be free to turn without any play in the boxes. It is quite a particular job, and one that requires considerable care and judgment, to so regulate the packing that, while there will be no play in the boxes, they may not bind upon the journals; for a very slight pressure will cause them to heat, while a very little play will make small corrugations upon the face of the lumber that is being planed.

Care should be taken in grinding knives and cutters, so that they may be kept in perfect balance. If a new set of knives are in perfect balance, it is an easy matter to keep them so if sufficient care is manifested in grinding.

The side-cutters should also have close attention; and no matter what style of head is used, the cutters should be kept not only sharp and in good shape, but especial care should be had in filing or grinding, to keep them of the same weight.

The cutting edge of a matcher-bit seldom exceeds two inches in width; so, that if they are all of the same thickness, and kept the same length, they will always be in running balance.

Bad belts are not only a great annoyance to the operator, but sometimes a source of great damage to the machine. There is no economy in running crooked belts, flopping about from one side of the pulley to the other, with thick, hard laps that spring the shaft every time they pass over the pulley. The sooner such belts are dispensed with and consigned to the junk-heap, the better it will be for the proprietor, and save a great deal of time and *swearing* on the part of the operator.

It is a fact that may easily be demonstrated in most planing-mills, that the time spent in the course of a year in patching and sewing old belts, if carefully taken and kept an account of, would amount to a sum sufficient to more than pay for new ones. When a belt becomes so rotten and worn that it requires mending every few days, the cheapest plan is to mend it at once with a new one.

The matcher-belts require more care and should be of better quality than any other belt about the machine. From the manner in which they run, they will get crooked no matter how good they may be. When they get so, if they are not attended to, they will run to the top of the pulley and soon cut themselves to pieces against the upright. In order to keep them in shape, so as to run well and remain on the pulleys in their proper places, they should be (especially when new) turned every day; and. even after they are done stretching whenever they are inclined to ruu high upon the pulley, this may be corrected by turning them over on the pulleys.

I once had a case of this kind, which is cited to illustrate how little judgment and forethought some men manifest in the management of machinery.

A medium-sized machine was sold to a party who claimed to have a man of large experience as a planing-machine operator to take charge of and run it. After a few weeks, a letter was received, stating that something must be done with that machine, for the matcher-belts run over the tops of the pulleys and cut themselves to pieces in a short time, and that he had already used up two new sets of belts. His foreman thought there should be flanges on the upper end of the pulleys, but the back-shaft was too high and should be lowered; in fact, every man in the mill had a remedy for it, except the right one.

I called on him, and he informed me that he had put on a new set of belts only a day or two previous; and they had already began to act in the same manner as the others had done. I asked the foreman if he had ever turned them. He replied no; that he had never heard of such a thing before. He had run So-and-so's machine for six months before, and never had any trouble of that kind with the belts.

The belts were taken off and laid out on the floor. Instead of being straight, they described a circle of twelve or thirteen feet radius. The belts were turned end for end and put on again, when, instead of running up on the pulleys, they ran down hard on the bottom flanges for a while, and then worked up to the centre of the pulleys, where they remained. I advised him to turn the belts frequently, and they would give him no further trouble. And as there were no further complaints, I concluded that the suggestion was acted upon.

It is well known among all skilled mechanics that all quarter-twist belts, where the upright shaft is at right angles to the driving one, will find their own natural position upon the face of a pulley, no matter whether it is crowning or straight on the face, so long as the relative position of the two shafts remains unchanged; and where an upright shaft is driven by a pulley on a horizontal one, as is the case with the matcher spindles of a combined planing and matching machine, the leading side of the belt, or that side which is running towards the driven pulley, will always follow a line at right angles with the upright and the top or driving side of the belt. That being the center of the pulley, one half of the width of the belt will run above that line, and the other half below it, provided the belt is perfectly straight; and as long as these conditions are fulfilled the belt will run in the centre of the pulley upon the upright shaft.

It is also well known to all practical men that the position of a quarter-twist belt is such that the strain upon the upper edge is much greater than upon the lower. And when the belt becomes stretched out of a straight line, it has the same effect as changing the angle of the upright shaft; and the belt will run above its real path just in proportion as it would vary from a straight line provided it was taken off and laid upon the floor. Hence the necessity of frequently changing such belts by turning them over; and all quarter-twist belts, no matter what their size or width or for whatever purpose they are used, should be joined together by fastenings that will admit of either side being run next to the pulley

CHAPTER XIII.

FEED-ROLLS—MANNER OF CASTING THEM—TROUBLE CAUSED BY IMPERFECT ROLLS, IMPERFECT GEARING, ETC.

THE feed-rolls of a planing-machine, although not requiring the same mechanical skill and judgment as the cylinder and side cutters, should be carefully and accurately fitted. In most cases, they are cast upon the wrought-iron shafts that are used for their bearings, and to which the driving-gears are attached. If the shafts are heavy and properly prepared, the rolls may be cast upon them so as to be as strong and durable as any other means of fastening. The trouble experienced in many mills by the rollers working loose upon the shafts is in the imperfect manner of preparing them before being taken to the foundry.

In many cases, where rolls have been brought to the shop for repairs, upon examination it was found that only a few shallow holes had been drilled into the shaft at that point where the iron closes around it, the centre being cored out, leaving a bearing of from one and one half to two inches upon each end, the balance forming a cylinder of about one half inch thick.

The coring out of the centre is well enough, as a round cylinder one half inch thick is strong enough to stand all the strain that would ever be brought to bear upon it. But the short bearings at the ends, and secured only by a few holes drilled into the shaft, is not sufficient to hold it; and with rolls cast upon the shafts in this manner, it will only be a question of time when they will work loose.

All practical mechanics should know that the shrinkage of cast and wrought iron is not equal, the latter expanding by heat and contracting by cold more than the former; and as that part of the shaft which comes in immediate contact with the melted iron becomes as hot as the casting in a few minutes, when both cool off together the wrought-iron will shrink more than the cast and have a tendency to draw away from it unless some provision is made to counteract this tendency. If not, in nine cases out of ten, a slight jar *will* start them loose from the shaft before they leave the foundry.

The most effective manner to prevent this defect is: In the first place, there should not be less than three inches bearing on each end of the roll where the wrought and cast iron come in contact. This may be done by casting collars upon each end of the rolls long enough to fill up the space between the boxes and the end of the roll.

That part of the shaft which comes in contact with the casting should be turned down just sufficient to insure a clean surface; for the cast-iron will not lay upon the surface if there is rust or other foreign matter adhering to it, but will boil and bubble so that the surface in contact, instead of being smooth and solid, will be spongy and of no use.

Heating the bar white-hot and while in that state, if all the rust and scales are carefully scraped off and the iron used as soon as it cools, will answer the same purpose as turning, so far as the casting is concerned.

After the shafts are prepared, either by heating or turning, the spaces should be laid out so as to indicate where the cast and wrought iron are to meet. Then cut three or four square slots similar to a key-seat,—except they should begin near the end of the roll,—about three eights of an inch deep, and taper towards the centre so as to run out near the inside edge of the casting. These slots for a shaft two inches in diameter should not be not less than one half inch wide.

Now, when the melted iron is poured into the mould it runs into these slots, and that part of the bar soon becomes as hot as the casting. But the centre of the bar, being protected by the core, will not be heated much above a red heat; so that, when the whole cools, the casting will shrink endwise more than the bar, and the ends will be drawn towards the centre upon the inclined surface at the bottom of the slot, so that, the more they shrink, the tighter they will become. Rolls cast upon the shafts in this manner, with proper care in fitting up, will never get loose.

The shafts are frequently sprung by the intense heat in casting, so that they require straightening before they are turned off. When such is the case, never lay them on the anvil and pound them with a sledge, as is frequently done, for that will be liable to start them loose, no matter how firm they may be. If they require straightening, the proper way is to use a press and spring them with the power of a screw. This is easily accomplished, for that part of the shafting close to the casting is always quite soft, being annealed by the intense heat of the melted iron that surrounds it.

In fitting up rolls, it is important that they be perfectly round of the same diameter, straight from end to end, and true with the journals. There is more trouble caused by imperfect rolls than many are aware of. If they are not true with the shafts or journals, and run out—especially the bottom ones—at every revolution, they will lift the board from the bed unless the pressure-bar or roll in front of the cylinder, as the case may be, is weighted down sufficiently to spring the board and prevent it from lifting.

This will do very well for thin stuff; but with lumber two or three inches thick, if the pressure is set so close as to prevent it from raising, it will stick every time the high side comes up, and the machine will feed by jerks and make imperfect work. Again, if the feed-rolls vary in size, no matter how small that variation may be, one or the other must slide upon the surface of the board; for they are so geared together that each pair are compelled to make the same number of revolutions in a given time. And it is evident that this unnatural strain upon the extension-gears, if not sufficient to break the teeth, will soon wear them away so as to render them useless.

My attention was once called to a case of this kind which fully confirms what has just been said. The machine was a heavy six-rolled one of a certain well-known manufacturer, and was really a first-class machine; but the owners were having trouble with the extension-gears on the rolls behind the cylinder. They informed me that the gears on both pairs of the rolls in front of the cylinder had never given them any trouble, and the same gears were on now that came with the machine and were in good condition; but the pair behind the cylinder had always given them trouble—had broken and worn out three sets already.

This machine was provided with a steel scraper, attached to the top roll to prevent the accumulation of gum; and it had performed its duty so well that it had not only scraped off all the gum, but it had scraped off the roll also, until it was fully one eighth of an inch smaller than its mate; so that the gears had not only to perform the duty of carrying the board along at its regular feed, but to overcome the friction of one roll constantly sliding upon its surface—so that this set of gears were doing double duty, as compared with the others.

The remedy suggested was to take all the rolls to the machine-shop, and have them all turned to the same size; then throw the steel scraper into the scrap-heap, and in its place apply a piece of hard wood covered on the side in contact with the roll with about three thicknesses of stout felt or cotton duck, and so adjust it that it would press lightly upon the roll, and, by the use of a few drops of kerosene oil applied once or twice in the day, the roll would be kept clean and there would be no further trouble from the wearing out or breaking of gears. This plan was adopted, and there was no further trouble with the machine.

Good, smooth-running gearing is essential to a well-working machine. It would seem as if some manufacturers had expended all their mechanical skill and ingenuity on their machines before the gearing was arrived at, and that part left to chance; and as if they had picked up the first thing for a pattern in the shape of a gear that might be of the right diameter, regardless of pitch or width of face. Others seem to have given this subject considerable attention, with well proportioned patterns. But after all, there seems to be no standard for pitch or width of face, some going to one extreme and some to the other. On one machine may be found gears with very wide face and fine teeth; while another will go to the opposite extreme, of making a very narrow face, with the pitch coarse enough for mill-gearing.

Now, there is a medium for all things. Fine wide-faced gears for planing-mill purposes are objectionable for the reason that it is difficult to keep them in line, especially those which run loose upon studs and pins; and if they are not in line, and bear only on one half the width of the tooth, they are really no stronger than they would be if they were only one half the width of face. It is a mistaken idea that gears of medium coarse pitch cannot be made to run as smooth as fine-pitched gear.

In my experience, I have found that the most suitable proportions for the gearing of a heavy, first-class planing-machine should be two-inch face and one-inch pitch. If such gears are cast from good iron patterns, accurately cut, they will wear well, run smooth, and are less liable to break than any other proportion that has come under my observation. Wooden patterns are not suitable for this purpose; for, no matter how accurately they may be constructed, after using them a few times, the change from the moisture of the foundry to the dry air of the pattern-room will soon cause them to shrink and swell until they are anything but the proper shape for a good pattern.

All gearing, before they are attached to a machine, should be carefully examined; for, no matter how perfect the pattern, by a little carelessness on the part of the moulder there are liable to be teeth that are swelled, which, if not dressed off so as to correspond with the others, there will be a jerk every time that tooth comes in contact with the others: and much of the wavy and imperfect work which is complained of may be traced to this cause.

I was once sent for to examine a machine that had a trick of making corrugations on the face of the lumber about two feet apart, while the surface between was perfectly smooth. The operator in charge, who had only been in the mill a short time, and who was a very competent man, had puzzled his brains to discover the cause, and had given it up. I went for the gearing the first thing; and sure enough, there was a tooth in the intermediate gear that had been broken out, and some one not well skilled in *gear dentistry* had inserted one in its place which was neither the right size nor shape to agree with the others, and every time it came in contact with its neighbor it gave him a punch, who resented it by giving him a punch back: and the result was a small corrugation on the face of the lumber that was being planed. I took the gear off, and, with a file and calipers, reduced it to its proper shape and size, so that it would work smooth and regular with the others: and the corrugations from that time disappeared.

Very few operators are aware of the sensitiveness of a planing-machine, and seem to think that, if they have a good heavy machine, it ought to do good smooth work under all conditions and under all circumstances, which is not the case. And I once had an opportunity of demonstrating this fact to a party who entertained this notion. He had in his mill a heavy, six-rolled machine, weighing about nine thousand pounds, which he claimed was *cranky*. Some days, he said, it would plane perfectly smooth on any kind of work, while other days the work would be wavy in spite of all he could do, and he had failed to discover the cause, and claimed it must be some defect in the machine.

I looked the machine over carefully and could discover nothing wrong; and as it was turning out very smooth work at the time, I remarked that I was sure no one could complain of the quality of such work as he was then turning out. He said this was one of its good days, but he wished I could see some of the work that it turned out when it was "bulling," as he expressed it. I examined some of the work that had been done under those conditions, and was forced to admit that it was not first-class work. I examined the floor and the foundation underneath the machine, and found it fair, but not quite as solid as it should have been. I told him there was a cause for it, and I should stay there until I discovered it, "if it took all summer."

To satisfy him that a planing-machine was more sensitive than he was willing to admit, I gave the machine a good smart kick with my foot, against the side of the frame; and sure enough, when the board came out, although perfectly smooth in every other part, just at the point where it was working when I gave it the kick there was a small corrugation.

I then went up stairs, which was occupied as a sash and door factory, and right over the planer I saw a heavy power mortising-machine, but which was not running at the time. I requested the foreman of that establishment to start it up, which he did: and sure enough, just as soon as it began to work, the planer commenced to "bull," and the work was anything but smooth. I told him I guessed we had found the trouble without my staying "all summer," and that, if he wanted his planer to do smooth work every day without "bulling," he must take the "bull by the horns" and either remove the mortiser to some other part of the building or put an independent post under it reaching down to the ground, so that the mortiser would stand upon its own responsibility, and not communicate every vibration it produced to the planer below; also to put an extra post under the planer to help support the floor.

This was done, and from that time no more "bulling" was complained of.

CHAPTER XIV.

LUBRICATION—DEFECTIVE BOXES—THE SELF-OILING BOX—GLASS OILERS—ADULTERATED OILS—THE BEST OILS FOR PLANING-MILL PURPOSES.

As all wood-working machinery needs lubricating, it is unnecessary to say that without some system of lubrication no machinery can be successfully run.

The different modes and the great number of lubricants in use at the present time form a good and profitable theme for discussion. When two surfaces in working contact are brought together, no matter whether the motion is circular or reciprocating, unless some substance be introduced between those surfaces to keep them from intimate contact with each other heat and abrasion will result. Perfect lubrication cannot be had unless suitable boxes to receive and retain the lubricant are provided.

The old-fashioned box with a hole in the cap is still in use, and has its advocates. This may do well enough for some of the coarser kinds of slow-running machinery, but with fast-running machinery, of that class which comes under the head of planing-mill machinery, this box is out of the question for certain parts of the machine. The principal objection to this style of box is, the oil is not retained in the oil-hole, but runs down immediately upon the journal, and is thrown off by the rapid motion of the shaft and wasted, except what may adhere to the journal; and unless the operation of oiling be frequently repeated, the journal soon becomes dry and heated before the operator is aware of it. Enlarging the oil-hole, by cutting away a part of the cap so as to form a receptacle for a piece of suet, not only takes away just so much of the wearing surface, but materially weakens it, besides forming an excellent receptacle for dust and grit, which are carried in with the melted tallow and helps to cut the journal and wear out the box.

The self-oiling box introduced several years ago, and adopted by most of the leading manufacturers, was probably the best system that was ever adopted for lubricating fast-running machinery. This box was provided with a reservoir below the bearing to contain the oil, which was drawn up to the journal by capillary attraction through tubes inserted in the bottom of the box and filled with cotton wicking, sponges, or some other fibrous substance. Openings were provided at each end of the inside box which formed the bearing, so that the surplus oil drawn up through the tubes could flow back again into the reservoir after it had passed over the journal, and not be wasted.

This style of box had no oil-holes in the cap (the reservoir being filled when the caps were taken off), and was free from dust and grit; and as the oil was constantly filtered by being drawn through this fibrous substance in the tubes, the journals were always supplied with perfectly clean oil, while whatever impurities might be contained in the oil were left to settle in the bottom of the reservoir.

This style of box, although somewhat expensive, would run for months without re-oiling if properly taken care of. But the trouble was that, if a box would run successfully for three months without cleaning and being replenished with fresh oil, the chances were it would be neglected until the oil was exhausted, and before the operator was aware of it the journals would be cut or the metal lining melted out of the box.

We remember one case that came under our own observation. A line of shafting about ninety feet long was put up with self-oiling boxes; the speed was three hundred revolutions per minute, and the reservoir under each bearing contained about a pint of oil. This shaft was warranted to run six months without reoiling, but it was stipulated that at the end of that time the boxes should be taken out and cleaned, and replenished with a fresh supply of oil, when it would be good for another six months' run.

One day the foreman of the mill came into the shop where the shaft and boxes were made, holding in his hand one of the boxes with the metal lining melted out and the iron shell nearly cut through; the shaft was also badly cut in the journal. Of course he heaped all manner of curses upon the self-oiling boxes.

When he had sufficiently relieved himself, the proprietor of the machine-shop inquired how long since those boxes were cleaned and oiled.

He replied that he did not know,—there had been nothing done with them since he had been in the mill.

"And how long have you been in the mill?" inquired the proprietor.

"Well, let's see," replied the foreman: "I think it is a year last month."

"And how long had the mill been running when you took charge of it?"

"I don't know exactly," replied he.

"Well, I know," replied the proprietor. "The mill was first started on the third day of April, and you took charge about the first of June following; so you see, according to your own statement, that shaft has been running constantly every day for about fourteen months, without cleaning, oiling, or any other care whatever; and the only wonder is that, instead of one box being cut out, they were not all cut out, and the mill set on fire long ago from hot journals."

Another case was a planing-machine that had been in operation a little over a year when the writer visited it. The cylinders were fitted with self-oiling boxes of a capacity to hold sufficient oil to last three months. When I visited the mill I found each box fitted with a glass oiler. I inquired how the machine was working. He replied. "All right;" but his foreman said the self-oiling box was a failure and had condemned them and substituted the glass oiler in their place.

Upon further inquiry I learned that for about three months the machine ran all right, and then began to heat so that it could not be run. I asked him if he would stop long enough to allow me to examine the boxes. "Certainly," he replied.

The caps were taken off and the cylinder taken out, when the reservoirs below the journals were found to be full of a substance resembling gutta-percha, and nearly as hard. I asked him if those boxes had ever been taken out and cleaned. He replied that they had not, to his knowledge.

This explained the whole matter. They had run until the oil had become so thick and exhausted, that it could not feed through the tubes; as there were no oil-holes in the cap, the journals became dry and hot as a natural consequence; and instead of cleaning them out, he condemned them and put in glass oilers.

In this manner the good intentions of the manufacturer are defeated by the ignorance or carelessness of the operator; and many excellent devices that would be real improvements if properly treated are condemned as failures when it is really the operator that is the failure, and not the device.

This is not intended to apply to all operators of planing-mill machinery; for I know personally many good, careful, intelligent men who are thoroughly acquainted with their business, and who appreciate good improvements, and take an honest pride in keeping the machines under their charge in perfect running order. But such men, however, are scarce—not but what many more might be had if the proprietors of planing-mills were willing to compensate them according to their abilities; but the mistaken policy of employing *cheap* men to take charge of their mills is a fruitful source of annoyance to the manufacturer and small profit in the end to the owner.

Notwithstanding the self-oiling box has been condemned by many planing-mill operators, and abandoned by many of the manufacturers, yet we believe that, with proper care and the use of good oil, no other style of box is equal to it for safety and economy in the use of oil, besides the extra time that a box will last without rebabbitting.

But if the majority of those who have the care of them will not attend to them and keep them in a proper condition, then something else must be substituted that will keep the journals lubricated without danger of running dry and heating. The liability of melting the metal out of the boxes is not the only danger to be apprehended; for in nine cases out of ten the journals, which are of cast-steel, become hot enough to melt out the metal lining, the shaft will be sprung so that it will require to be taken to the machine-shop to be straightened, and then, unless the straightening is done by a skilful workman, and one who has had experience in such matters, the chances are that the first time it gets warm it will go back again, and in this way become a source of constant annoyance.

The glass oiler inserted into the cap of a common box is the next best substitute for the self-oiling box. But they also have their disadvantages as well as their advantages; and where they have been introduced to any extent, they have not in all cases been entirely successful. They require more watching than the self-oiling box, for the reason that they hold less oil and sooner run dry. And if they happen to be set to feed too fast, the oil runs out and is wasted; and if set just fine enough to supply no more oil than is required for lubricating the journal, the least speck of dirt will stop the feeding entirely, and a journal will run dry before the operator is aware of it. The only redeeming feature that can be discovered is that, being of glass, it is transparent, and, if the oil runs out, the operator can discover it; but if the glass gets broken the first week, as it is liable to in a planing-mill, then the operator generally pulls out the wire and pours the oil down the tube whenever he thinks it may need it, regardless of quantity, until a new one is provided—which is not very soon, unless there happens to be an extra one on hand to take its place.

Under all these circumstances, the most practical box for planing-mill purposes is a good common one with a long bearing, and lined with the best anti-friction metal that can be obtained, and the caps provided with circular oil-cups large enough to hold a good-sized piece of sponge or cotton-waste, with close-fitting covers working upon a hinge or pin, so that they cannot be lost off. A small hole should be drilled through the cap in the centre of the oil-cup to admit the oil to the journal. And when this oil-cup is filled with sponge or cotton-waste, and well saturated with oil, if the covers are carefully closed to keep out the dust and grit, the oil will filter gradually through. This constitutes about as good a box as any for all practical purposes; and if good oil is used, and no more applied than sufficient to keep the fibrous substance in the cups saturated, it is astonishing what a small quantity will answer the purpose.

The selection of the best and most profitable lubricant to be used is a subject upon which there is a wide diversity of opinion among planing-mill owners. They are constantly besieged by dealers in oils, who have everything to offer as "the best," from the best sperm oil down to a keg of coal-tar. And a great quantity of the stuff which is sold to those who do not understand the correct theory of lubrication, to be used on fine, fast-running machinery, is not fit to grease a cart; and every dollar saved on this cheap stuff is two dollars thrown away on extra repairs. The old maxim "The best is the cheapest" may well be applied to lubricating-oils.

The correct principle of lubrication, as I have said before, is to introduce between two wearing surfaces a substance that will prevent those surfaces from coming in intimate contact with each other. And the substance that will best fulfil this condition the longest with the least quantity used, without becoming thick and gummy, is the best, no matter what it is composed of.

Pure sperm oil probably contains the best lubricating properties of any other oils, as it is comparatively free from gelatine, has but little affinity for oxygen, and consequently will not gum, but retains its fluidity until worn out. But the high price of the pure article, and the difficulty of obtaining it pure, together with the reckless manner in which oils are used by most operators, render it too expensive for general use.

Next to sperm, pure winter-pressed lard-oil is the best, provided it can be obtained pure. But competition among the manufacturers of lard-oil has led to a variety of adulterations. Cotton-seed, rape-seed, and peanut oils, with paraffine, and the Lord knows what, are the most common adulterations that render it gummy and unfit to use on fast-running machinery.

Hydro-carbons or mineral oils are extensively used for this purpose, varying in quality from the lightest and most volatile down to a substance but little better than coal-tar; and each grade has its advocates. But from careful observation and a close examination of the chemical properties of this class of oils, I have failed to discover the lubricating properties claimed for them. A journal may be run with clean water without heat or abrasion; but that does not prove that water is a good lubricator by any means. Water has not the consistency or body to prevent the surfaces from coming in intimate contact with each other; consequently, the surfaces are rapidly worn away and the box is soon worn out.

This, to a certain extent, is the case with most of the hydro-carbons unless they are mixed with animal oils. If they are clean and clear, they are so light and volatile that, when so used, there is not sufficient body to them to keep the surfaces from intimate contact; while in the thick dark-colored oils that appear to have body, that body is composed of an earthy, carbonacious substance with more or less grit held in suspension, so that the cushion that it forms between the surface wears away the box about as fast as it would if it had no body at all.

From long experience in the use of various oils and lubricants, I am of the opinion that pure lard-oil is the cheapest and best for fast-running machinery. It is true that in the winter a planing-mill is a cold place, and lard-oil becomes thick with the cold; but this may be remedied by mixing with about one third refined petroleum. This will prevent it from becoming chilled, and can be used in the coldest weather. One barrel of pure lard-oil, if used carefully and economically, will last as long and do as much work with less damage to the machinery as three times that amount of the stuff that is sold under the name of lubricating-oils. My advice to planing-mill owners is to buy nothing but the best lard-oil; and then, if they choose to adulterate it with paraffine, kerosene, or any other substance, to do it themselves, as they can not only do it cheaper, but have the satisfaction of knowing what the adulteration is composed of.

CHAPTER XV.

HINTS ABOUT MOULDING-MACHINES—THE MOST DESIRABLE SIZE FOR PLANING-MILL PURPOSES—THE BEST MATERIALS FOR CYLINDERS, AND THEIR STYLE—SOLID CUTTERS—SECTIONAL CUTTERS USEFUL, ETC.

IN the list of planing-mill machinery, next to the planer and matcher the moulding-machine is one of the most importance. As nearly all lumber-dealers keep a stock of mouldings on hand, the moulding-machine has become indispensable to all well-equipped mills. The market is full of machines for this purpose, and a purchaser can find anything he may desire from the best to the poorest; from a machine that will weigh 500 pounds up to one that will weigh 5000.

Some of the manufacturers of a machine that will weigh 500 or 600 pounds will *swear* by their machine that it is as good and will do as much work as the heaviest.

It is not our object to recommend any particular machine, or to speak of the machines of any particular manufacturer; but the object is to point out and describe the qualities required for the most suitable machine for planing-mill purposes. And if John Doe, Richard Roe, Sam Jones, or John Smith make a machine that comes up to these requirements, that is the machine to purchase.

For planing-mill purposes, we consider what is known as the *inside* machine the best; *i.e.*, a machine with the cylinders working between the boxes in the same manner as an ordinary planer and matcher. This style of machine admits of a wider cylinder, and is more substantial and available for a greater variety of work than the machine with the over-hanging head. Besides, such a machine, when not required for mouldings, is available for other work, and may be profitably used on ceiling, siding, and matching; while a light machine with overhanging head is not well adapted to such work, and may stand idle one half of the time.

A machine of the style first mentioned, and to be suitable for the class of work referred to, should be built upon a good substantial iron frame of sufficient length to allow a good length to the cylinder and side-cutter belts. Short belts require more tension than long ones, and will not last as long—especially those which drive the side-cutters.

To give the necessary length of belt, the frame should be at least ten feet over all, with the back-shaft attached to it by suitable boxes having all the pulleys required to run the various heads attached, which should be turned perfectly true and balanced.

The cylinder should be at least twelve inches long and not less than six inches in diameter, and made either of cast-steel or gun-metal, with four sides, and furnished with slots on all four sides, so as to receive T-headed bolts in order that cutters may be attached anywhere on either face.

In some shops, soft, decarbonized steel is used. When such is the case, the steel will not be of a quality fit to form the journals. In such cases, the cylinder should be bored, and a good cast-steel shaft two inches in diameter should be inserted; but if good refined cast-steel is used, of the best quality, the journals may be forged on it and form one solid piece.

It is very important that the steel forming the journal should be close, of fine grain and uniform temper; for if there should happen to be hard and soft places, it will not run long before the journals will become imperfect and require turning off.

It is not only the delay and expense of having imperfect journals turned off every few months that the owners have to contend with. In many localities, a machine-shop may be a long distance from the mill; and when such shop is reached,—in many places, in the country shops,—the lathes are not suitable for such work, and many of the men employed have had so little experience in work of this kind that it is doubtful if the journals will be perfectly round when finished. It requires a first-class tool and an experienced man to do such work in a proper manner.

The boxes for the cylinders should be from ten to twelve inches long, and lined with the best anti-friction metal, and heavy enough to prevent vibration. This is a very important part; for no matter how strong a machine may be in all other parts, if the cylinder-boxes are not sufficiently heavy and well secured to the frame or bed-plate, so that they are rigid and steady and entirely free from vibration, smooth work cannot be expected.

The pressure-bars, or whatever device is used for holding down the stuff while being acted upon by the cutters should be made adjustable to and from the cutter-heads, so that when deep mouldings are stuck, that require the cutters to project beyond the cylinder a considerable distance, they may be moved far enough away to clear them, and, when light work is being done, to be moved up close to the cut of the knife, when projecting but little beyond the points of the cylinder. Provision should also be made in the pressure-bars for screwing on blocks of wood, as it is frequently convenient, when very light work is being run, to fasten a block of hard wood on the pressure-bar the reverse shape of the moulding, and bring it close to the knife—and thus prevent slivering and vibrations.

The side-spindles should be at least one and a half inch cast-steel, with that part which projects above the bearing fitted to receive whatever style of cutter-head may be used and best adapted to the work. For ordinary moulding work the four-sided slotted head is preferable, and should be made of the same material and fitted up in the same style as the cylinders; but if the machine is used for matching a portion of the time, any of the approved styles of matcher-heads may be used.

The boxes which support the spindles should be strong, with long bearings connected together by strong hangers, and so arranged that either or both may be moved laterally by screws for that purpose. Some manufacturers gib these hangers to the bed-plate by means of suitable dovetails provided for that purpose; while others prefer to hang them upon round bars extending across the frame, and attached to it at each end. Either plan is good if the work is strong and well fitted.

The side-heads should be placed one forward of the other about one half the diameter of one head, so that when working on both sides of a piece the cuts will not be directly opposite each other. This admits of a suitable fence or guide on each side of the stuff for the opposite head to work against.

The pulleys on the cylinder shaft should not be less than four and one half inches in diameter, and wide enough to take a four-inch belt, and should be driven from both ends.

The pulleys on the side-spindles should be of the same diameter, with sufficient width of face to allow for the variations of a quarter-twist belt, which should be at least twice the width of the belt.

The peculiarities of a quarter-twist belt are, that when tight and straight it will run on the centre of the pulley, but when stretched out of a straight line and becomes loose it will run up; and as it is almost impossible to always keep it just right, the pulley should be wide enough on the face to admit of these variations. Another peculiarity of a quarter-twist belt is, especially when new, that one side will stretch so much more than the other, unless the belt is frequently turned, that it is a difficult matter to run it at all.

The feed-works should consist of two pairs of rolls not less than six inches in diameter, and connected by some good system of extension-gears, and weighted so as to give a strong and reliable feed to smooth-faced rolls. Fluted rolls on a machine of this class should never be tolerated.

We have described in the foregoing what we consider the best and most profitable machine for planing-mill purposes, because such a machine, when not required for moulding purposes, may be profitably employed on a great variety of other work that can be done on this machine to better advantage than on the planer and matcher.

Very few mills in the country have sufficient business to keep a machine constantly employed on mouldings, but a machine of the style which we have described can always find something to keep it constantly in use; while a light machine of small capacity, only adapted to ordinary mouldings, would probably stand idle half the time.

Much has been said about cutters and cutter-heads, but a few hints with regard to the various tools used in mouldings and the manner of using them may not be out of place in this connection.

It has become quite customary in many custom mills where mouldings are made to order to either use one knife, or *build up*, as it is called. This building-up is accomplished by the use of sectional knives, consisting of hollow, round, straight, and other shaped tools, so arranged on the cylinder as to form the correct shape of the moulding when adjusted to a certain pattern. With a few sets of such tools, almost any size or shape of moulding may be struck by different combinations of the same tools.

There is no objection to this manner of forming different combinations of tools, as it saves the expense of a separate set of knives for each size and shape, provided such sections are made in pairs and perfectly balance with each other. But the practice of using but one tool of each shape is a bad one. We often meet with cases where a machine is set up with a hollow on one side, a round on the other, and a straight on the third; and if no other shape is needed, any tool or a piece of iron is fastened to the fourth side to form a *balance*,—neither one of the same length, width, or shape, nor opposite to each other,—and the machine started. If, after starting, the machine jars so badly that it cannot be run, it is stopped and an extra washer or piece of iron is added, and then it must go whether it balance or not; and probably when the job is finished one half of the bolts and set-screws in the machine are jarred loose.

Another practice is to fit up one perfect knife to correspond to the shape of the pattern required, and then find a piece of iron that will weigh the same on the scales, and fasten that on the side opposite the knife to *counterbalance* it. This acts as anything but a counterbalance, as the roaring of such machines will satisfy any one within the radius of half a mile who will take the trouble to listen to it.

In order to counterbalance a knife in that manner perfectly, the counterbalance must be of the same weight, length, and thickness as the knife, for it is well known that the centrifugal force of all revolving bodies is to each other as the square of their velocities; hence if one portion of the knife projects 1 inch farther beyond the cylinder than the counterbalance, that part is moving in a circle 2 inches greater in diameter than the counterbalance.

Now suppose the longest section of the knife describes a circle of 7 inches diameter, and the projecting end of the counterbalance describes a circle of 6:

the difference in the distance traveled at each revolution would be 3 and $1\frac{1}{2}$ inches. Multiply this by 3000 revolutions per minute, and the difference in velocity is 875 feet per minute.

Now compare the square of 875 with the weight and distance from the centre, and we find that a small fraction of an ounce will be magnified into several fractions of a pound.

The noise and vibration are not the only objection: wavy and imperfect work also results (for smooth work cannot be done with an unbalanced head). The cylinder being out of balance, and not running on its true centre of gravity, in its endeavors to find that point which would be the true centre one side of the journal is constantly pressed against the box, bringing all the wear on one side of it. It soon becomes out of round, and the longer it runs the worse it gets; and it is only a question of time when it will not run at all without heating.

If preferable to make mouldings by the building-up process with sections, then these should be in pairs, perfectly balanced, and set so that each may do the same work; then the cutters which form the moulding, no matter how many pieces they may be composed of, will run well and do smooth work. If one full knife is used with a counterbalance, then get a piece of the exact length, thickness, and weight, and file it up nearly or quite to the shape of the knife which is to be used; set it back just far enough to clear the stuff; then, if the feed is in proportion to the speed of the cutter, good fair work may be done without material injury to the machine. But as only one half of the work ought to be done with one cutter in a given time, if there is much to be furnished it will in most cases pay better to build up or to fit up a complete pair.

CHAPTER XVI.

SOME OF THE DIFFICULTIES MANUFACTURERS MEET WITH — INEXPERIENCED MEN — PROFESSIONAL HUMBUGS — CARELESSNESS ONE OF THE CAUSES OF TROUBLE—THE OPERATOR IN HIS OWN ESTIMATION NEVER AT FAULT.

HAVING pointed out in a former chapter some of the difficulties operators labor under from imperfect machines, I now propose to point out some of the difficulties manufacturers labor under from imperfect operators; and here let me say there is no class of manufacturers that have more to contend with in this respect than those just mentioned.

The rapid motion of the more essential parts of all wood-working machinery renders it important that each part should possess the requisite strength, be well fitted up, and in perfect balance. To adapt and apportion the several parts of a machine so as to give the greatest strength to the parts which sustain the greatest strain is the most important point to be considered in designing any kind of wood-working machinery.

At the present time there is scarcely anything made of wood but wood-working machinery of some kind used in forming it; and in looking over the lists of the different manufacturers it will be seen that a vast amount of labor and skill has been expended in this line of machinery.

Now, while it requires mechanical skill and judgment to properly construct and put in order any of the several machines referred to, skill and judgment are also requisite to keep them so; and I repeat what I have said before,—that no machine will run well and do good work unless kept in proper order, each part properly adjusted to its work; and the more perfect adjustment, the more perfect work.

The proprietors of some factories are well aware of this fact, and purchase the best machinery in the market regardless of cost, and employ none but skilled workmen in each and every department, the whole superintended by the most competent man that can be obtained—salary being a secondary consideration.

Such mills are always in a prosperous condition, as the superior quality of their work is sufficient inducement to others to place with them their orders. It is a pleasure to the manufacturer to place his machinery in such mills. The proprietor or superintendent—whichever does the buying—may be particular and exacting in many respects, but when he has complied with their wishes, and placed his machines in their mill, he will have the satisfaction of knowing that they will be well taken care of and kept in good order; and if the same are composed of good materials and well fitted up, he need not fear the record of those machines.

Other parties pursue just the opposite course. They buy the cheapest in the market (*i.e.*, that which costs the least dollars and cents, regardless of quality), and employ their men upon the same principle,—those who have had more experience in a cornfield than in a planing-mill. And such men are employed and put at work, often under the superintendence of a foreman at nine or ten dollars per week.

The mill is ready after a long time, and the several machines are belted up and started. Some go, and some do not. The journals heat, and there seems to be something wrong with every machine. No doubt there is; for they are probably set up just as they come from the shop, without knowing whether they are level and out of wind, or whether the several parts are properly adjusted, or even that the knives, if they happen to be on the cylinders, are screwed down or not. If one happens to fly off and break something, the manufacturer gets a blessing, and some country blacksmith will get the job of mending it, providing it happens to be something that can be patched up; and by the time they get the mill running, and it has run three months, the machines are so banged up that they look as if they had been in use ten years.

No wonder such parties complain that there "is no money in the business," and wonder how it is that A, B & Co. can afford to buy such expensive machinery and pay such wages to their men,—especially their foreman, who does nothing but walk around the mill, while theirs is constantly at work,—and yet sell their goods at the prices they do.

It is plain to be seen by any one that *will* see, that A, B & Co.'s machinery is running constantly like clockwork, and turning out more than double the work in the same time that they are, and of a much superior quality, while they are not turning out more than half as much as they should when running, besides being stopped one quarter of the time by breakdowns.

The former might have been avoided by purchasing good machinery, the latter by employing competent men to run it. They find out, often when it is too late, that their cheap mill and cheap men have been to them a dear investment, besides a constant source of annoyance to the manufacturer who furnished the machinery.

This is why I claim that manufacturers of wood-working machinery have more to contend with than almost any other class. It makes but little difference whether a machine is sent out from a first-class shop or one that makes a specialty of cheap work; for no matter how well made, if a machine is not carefully set up and kept in proper adjustment, it will not do good work.

A manufacturer of iron machine tools has less to contend with. He sells a lathe, a drill, or an iron-planer. The purchaser in most cases is a practical machinist himself; if not, his foreman is. The tool goes into the hands of a practical machinist to run it. If there should happen to be some little imperfection that was overlooked in fitting up, he discovers it at once, and in most cases goes to work and remedies it without saying anything about it; while a planer or moulding-machine that might be a little tight in the boxes is frequently started up by some inexperienced man, and after running a short time the journals get hot and melt the metal out of the boxes. Then the manufacturer gets the benefit of sundry curses, and the machine is condemned as a failure; when the fact is, it is the man who is the failure, and in most cases a greater one than the machine.

A case that will serve to illustrate this came under my own observation a few years since. A firm in the eastern part of this State (New York) purchased a medium-sized planer and matcher to be run in connection with their boat-yard. It was mentioned in the agreement that the manufacturer should be present and superintend the putting up and starting it.

The machine arrived in due time, and the proprietor, Mr. T., was duly notified. When he arrived at the mills and inquired for the foreman who was to have charge of it, he was informed that they had none, but expected, after he had put the machine in good running order, that any of the men in the yard who needed lumber dressed would use the machine for that purpose. After explaining to them the absurdity of the thing, and telling them plainly that he would not warrant the machine for two hours after he left it, they concluded to call in Jakey, the foreman of the boat-yard and have him learn to run the machine.

Now, Jakey had never examined a planing-machine, nor seen one running; consequently he knew nothing about it. But Jakey was a very intelligent German, and took hold of the machine under Mr. T.'s instruction, and in a couple of days got sufficiently acquainted with it, so as to be able to do very good work.

But after a few days they concluded that Jakey's services were worth more to them in the boat-yard than in the mill; and they had also learned that they must have some one to take care of the planer besides the men in the yard. Jakey advised them to hire some good man who had been accustomed to such work, to take the charge of the machine and do the planing.

One day a chap came along with a bundle of samples of matching, mouldings, and other work under his arm, and applied for the job, saying that he had run nearly all the different styles of planers in use, and more especially those of Mr. T.'s manufacture, and offered to work for ten dollars per week. This, they thought, was just the man they had been looking for, and hired him at once. When they asked Jakey what he thought of him, Jakey shook his head and replied, "Well, I guess dot fellow he knows too much and is no goot."

Jakey had been doing very good work, and the machine was in very fair working order; but our hero said the machine was out of line, and, before he commenced to operate it, he must "line her up."

Jakey told him he thought "'twas better off he wait a leetle and let it alone for awhile." But our hero understood his business; so Jakey retired to the yard and left the field open for him.

After working at the machine four days, he finally told the firm that the machine was not built right, and never could be made to do good work without some alterations which he suggested. Mr. T. was telegraphed to come on at once, as "the machine would not work."

When our hero found that Mr. T. had been telegraphed for, and would be there the next morning, he said he thought he would quit, as he was quite sure Mr. T. would not be willing to make the alterations that he required, and he was not willing to stay unless they were made; so he left. And after he was gone, Jakey remarked, "I guess 'tis better off he had quit before he come here."

Mr. T. arrived in the morning, and found the machine with the bottom rolls about a quarter of an inch above the bed-plate, and every other part of the machine out of place that could be got out, and some boards lying on the floor that had passed through the machine that would have done well for washboards. Mr. T. quietly informed the parties that their man was possessed with altogether too much wisdom for a planing-mill, and that he would go home and send a man to put the machine in order again by their paying time and expenses, and advised them to hire no more tramps that carried a bundle of samples under his arm; and that if they could not spare Jakey, to select some good intelligent young fellow out of the yard, and let Jakey and the man he would send break him in.

This they concluded to do, and a young man was selected to help Jim the man who was sent (from the factory); and between him and Jakey they made quite a competent man of him, and had no further trouble with the machine.

Now, if the owners of planing-mills do not feel willing to start up with a full force of skilled men, then hire the very best man that can be found for a foreman (no matter what you may pay him, he will be the cheapest in the end), and then let him educate his own men; and in a short time the mill will be not only supplied with competent men, but men that you know and can depend on.

CHAPTER XVII.

RESPONSIBILITIES OF FOREMAN—SYSTEM IN MANAGEMENT—A CONTRAST—FOUNDATIONS—LEVELLING FROM CERTAIN POINTS, ETC.

As we have before stated, to successfully operate a planing-mill it requires considerable skill and judgment—in fact, as much as any other branch of mechanical science.

It is true that, to become an expert operator, it is not absolutely necessary that he should serve a regular apprenticeship at the machine business in order to know when a machine is in a good running order; neither is it necessary to learn the joiner's and carpenter's trade in order to be able to turn out good matched flooring, siding, and mouldings. He should be able to adjust all the different parts of the machines under his charge so as to get the best results with the same degree of certainty as the manufacturer himself; and if repairs or alterations are required to meet the requirements of the trade, he should be able to give the necessary directions to the machinist in an intelligent manner.

The responsibilities of the foreman in charge are not simply confined to turning out good work, but often the lives of those under his charge may be endangered by his neglect or carelessness. If a knife flies off and kills or cripples the man or boy who may be feeding the machine at the time, in nine cases out of ten the foreman, if not strictly, legally responsible, is morally so. A knife will never fly off from the cylinder of a well-constructed machine if it is properly fastened in its place; and it is the business of the foreman to know that it is. I could point out mills that have run for years without an accident of this kind; while others that have not run as many months have had numerous smash-ups of this kind.

I visited a mill not long since which had run about six years; and during that time there had never been an accident or breakdown to amount to anything worth mentioning. The foreman I found to be a very careful, intelligent man, and one who understood the care and management of machinery about as well as any one I had met. He was not a machinist by trade, but his ideas of machinery were far better than many who were. He informed me that he never allowed one of his men to set the knives on a machine.

"When the knives get dull," he said, "I always have an extra set on hand for each machine, ground up and ready for business, and it takes but a few minutes to make the change; and if I do it myself, then I *know* how they are set. Besides," said he, "I often find a bolt that is strained and beginning to show weakness or the thread defective. In such cases I throw it aside, and substitute a new one. Then I know for myself that everything is all right. Another thing," said he, "I never allow the men to meddle with the boxes except to keep them well oiled. My orders are that if a box gets loose, or heats, to report it to me, and I attend to it: that's what I am here for."

In his toolroom there were shelves on which were arranged extra knives, bolts, nuts, and side-cutter heads, with the cutters all set and ready for use, so that when one set became dull, instead of stopping the machine while they were filed or ground up, it was only stopped long enough to make a change of heads, when the former were taken to the toolroom to be put in order again. He remarked as I was about to take my leave, that his "machines put in full time and earned their keeping."

It is a pleasure to visit such mills, and a misfortune that there are not more mills in the hands of just such men. I called at the office, found the proprietors cheerful and pleasant, and, when asked about their business, said everything was pleasant and their mill was paying a good profit, and that they had a good man in charge of it. He was a high-priced man, but they guessed he was the cheapest after all; but that $1500 a year was considerable money to pay a foreman. I ventured the remark that he was a cheaper man for them at that price than some others which I could mention would be at $500.

I visited another mill in the same town, and, oh, what a contrast! I first called at the office. The proprietors complained of low prices and the running expenses of the mill,—that there was no money in it,—and finally said that, only for keeping their trade (they were large lumber-dealers), they would shut the blamed mill down: for, except the first six months, it had never paid expenses—supplies and repairs eat it all up.

I went over to the mill, which was about a quarter of a mile from the office. I found four planing-machines, one moulding-machine, one resaw, besides a double-edger and other necessary equipment. The machinery was originally of first-class manufacture and well fitted up. I waded through shavings nearly up to my knees to a planer which was standing idle, while the young man who ran it (when it did run) was grinding his knives on a stone that was full of lumps and hollows and flat spots. I asked him why he did not turn it off and true it up. He replied that he didn't have time, as there was a lot of stuff to be got out that parties were waiting for. I suggested that there was always time saved by keeping tools in order, and that a grindstone was one of them. I then inquired for the foreman. He said he was not in; but if I would go across the street to a place that he pointed out, I would probably find him, as that was where he generally "hung out" out when absent from the mill. I walked over and, sure enough, found him sitting by a table, with a glass of lager in front of him; and judging from his appearance, I concluded that the cares and responsibilities of the planing-mill on the other side of the street did not weigh very heavily upon his mind, or else they were so heavy that he was obliged to resort to frequent glasses of lager to help him sustain the load.

As I said before, the proprietors of this mill had their wholesale yard and mill in one part of the town, and their retail yard and office in another. And that one of the proprietors visited the mill at stated times twice each day; and as the foreman generally managed to put in the time before he came around in cursing and finding fault with each man in the mill, his energies became so exhausted that, after the proprietor had made his round, he found it necessary to go across the street to recuperate his strength with a glass of lager; consequently, the proprietors did not know just how the thing was running.

The fact was, the mill had been well acquipped at first and furnished with the same class of machinery as the one which I first visited, but neglect and carelessness had nearly ruined every machine in the mill. The toolroom would give any practical man the horrors to see the broken knives, banged-up cutter-heads, and broken saws that would not be recognized by their maker.

I learned that, when this mill was first started, a competent man, recommended by the manufacturers, was employed to take charge of it; but after six months, the proprietors conceived the idea that they were paying too much, and a cheaper man was substituted. And in one year from that time the condition of the mill was as I have just stated.

Before leaving the town, I called again at the office, and the proprietors asked me what I thought of it. I told them that, at the rate their mill was running, there would be a good chance for somebody to put in a new set of machinery before many years. They said there was a "screw loose" somewhere. I asked him what time he visited the mill in the morning; he said at nine o'clock. I advised him to visit it at nine o'clock the next day, as usual, and then go over again about eleven, and I thought he would find where the loose screw was.

I have since learned that he followed my advice; and the result was that they not only found the loose screw, but that the old foreman was sent for and he is now in, charge of the mill. But after looking it over, he plainly told them that it would take him six months to get everything back in good shape again, and use up all the profits of a year's business.

A beer saloon may be all right for the purpose intended: but my opinion is that it is a poor place to run a planing-mill; and the sooner the proprietors find it out, the better it will be for them.

I do not wish to be understood that it requires every man and boy to be a mechanical expert; on the contrary, the majority of the work may be done by cheap and what is generally termed unskilled labor. But I do insist that, in order to operate a planing-mill successfully and profitably, at least one man at the head of it should be a competent and expert operator; and he should have the full charge of all the machinery, and devote his time to nothing else. I am aware that such men are not plentiful, and cannot be had for $10 or $12 per week; but enough can be had if planing-mill owners will pay them according to their abilities.

When a new machine is required to be set up, a good' foundation for it should be prepared, so that, when placed in its position and levelled up from the proper points. it will remain so. In the majority of mills, the floor is not always sufficient to sustain a machine, especially if it is a heavy one, without settling more or less; posts or stone piers should be placed under the legs, especially under the centre below the cylinder. It is not good practice for the machine to rest upon the stone pier directly, for there is a possibility of making a foundation too solid, as well as not solid enough. I once had a practical illustration of this fact, Quite a number of years ago I took a contract to furnish a mill complete. I was to furnish the plans and specifications for the building, furnish and put up all the machinery, and deliver the same to the company all in complete running order. The floor was well supported by heavy timbers resting upon stone piers, so that everything was solid and firm. For one large planer, weighing about nine thousand pounds it was thought advisible to build up an extra foundation. Accordingly, the floor was cut out and three stone piers laid up in water-lime to correspond to the legs of the machine, capped with a stone flag each about three inches thick, also embedded in motar, and levelled up so that the machine might rest squarely on the stone. When all was ready, the machinery was started, all working satisfactory except the large planer, which would invariably, after running an hour or so, leave the stuff wavy; and upon trying the cylinder boxes they would be found loose in the journals. In fact, no matter how well or nicely they might be adjusted, in less than an hour they would show the same defects again. After working with it for nearly three days with no more satisfactory results, I concluded to try an experiment. I had some pieces of wood got out one half inch thick and just the size of each foot, and placed them under them. The next morning, after carefully adjusting the boxes, the machine was started up; it ran all day, with the most satisfactory results, and there was no further trouble afterwards.

Stone foundations are all right, but they should only be built up to within two inches of the top of the floor, and then capped with a piece of two-inch plank;

and when a machine is placed upon such a foundation, and levelled up nicely, and every part adjusted, if it does not do satisfactory work, the fault is in the machine or the operator.

I do not approve of the plan of pulling a new machine to pieces just to satisfy the curiosity of the operator, as is the case in the many instances. Some operators seem to think that they must take a new machine to pieces in order to learn all the peculiarities of its construction.

A machine that is sent out from a first-class shop should be adjusted in every part ready for work except those parts which necessarily have to be removed for the purpose of shipment. And when the machine is placed in its position, levelled up, and those parts returned to their proper places and the belts put on, then, after being well oiled up, it should be ready for business. Considerable care should be manifested at first, and the bearings watched for a few days,—especially in cold weather,—where some of the bearings are long and the motion is slow, the oil may not flow freely over the whole surface readily at first; but after a journal has once become well covered with oil, then a very small quantity is required to keep it well lubricated.

In levelling up a new machine, operators often get into an error by levelling on the frame. There is not probably one machine in a hundred that the work exactly corresponds to the frame, except those parts where it is planed off; and by following the directions given in a previous chapter, there will be no difficulty in placing the machine in its proper position.

The bottom rolls in every planing-machine should be set far enough above the bed to allow for settling into the wood, and must be rated according to the weight that is sustained by the top rolls—ordinarily one thirty-second of an inch for the leading-in rolls, and about one half as much for those that deliver behind the cylinder. The reason for this is that, after the lumber has passed the receiving-rolls, the grain is compressed, so that it will not require the same allowance for the back rolls. It is well for the operator to examine this part; for no matter how well they may be adjusted in the shop, the jar of transportation frequently causes the nuts or screws to work loose and change their position, and thereby affect the adjustment.

The lumber, in passing through a machine, should rest firmly upon the bed-plate—otherwise it will be wavy; but at the same time the rolls should be so adjusted that it will not drag heavily upon it so as to cause unnecessary wear and strain upon the feed-works.

CHAPTER XVIII.

A SUITABLE OUTFIT FOR A SMALL MILL—MACHINES SHOULD BE ADAPTED TO THE WORK—A QUESTION OF POWER—ECONOMY IN FUEL BY THE USE OF A SUITABLY SIZED ENGINE.

IN ordering an outfit for a new mill, considerable judgment is required in the selection of suitable machinery to meet the requirements of the locality in which it is located. In a small town, for instance, where only a limited amount of work is required, and only one planing-machine needed to perform that work, a medium-sized machine to plane one or both sides, twenty-four inches wide and six inches thick, should be selected. This should be a machine that can be easily and quickly adjusted from one class of work to another, and changed from matching to surfacing without the delay of stopping to remove heads or belts. In those small mills most of the work is short jobs, and there is about as much surfacing required as matching; and a machine that can be changed readily, without loss of time, in ordinary cases will be able to do all the work required, and, if run constantly, it is better than to have two machines, with one standing idle more than half the time.

I am aware that many object to running narrow stuff on a wide machine, for the reason that it wears the knives in one place—also the points of the cylinder. But in this class of mills to which I refer there is ordinarily about as much lumber that requires only surfacing as there is matching; and if the machine is furnished with a guide on both sides (which all machines of this kind should have), and the stuff to be surfaced is always fed against the left-hand guide, while that which is to be matched is fed to the right, as a rule both ends of the knives and both sides of the bed will be worn about equal, and twenty-four-inch knives can at all times be used to good advantage. It is true, cases may arise when quite a large job of matching may be required at one time. In such cases, it would be well to have a set of short knives on hand to use on such occasions.

An idea seems to prevail among a certain class that a machine for these small mills should be adapted to all classes of work, such as planing and matching, sticking all sizes of mouldings—in fact, a whole planing-mill and sash and door factory combined in one machine; and one party inquired why a horizontal saw could not be attached to the same machine to resaw siding.

Now, my experience of over thirty years has convinced me of the truth of the old maxim "To attempt to do everything with one thing will spoil it for anything;" and this maxim holds good with machinery as well as anything else. Although machines are advertised to do all this, except the resaw part of it, I have yet to find one that was able to do perfect work on any class of work that was claimed for it.

A planing-machine to do first-class work, and do it rapidly, must be close and compact in all its parts; the pressure-bars as close to the cylinder as practicable, and the matchers as close to the pressure-bars as may be and give sufficient room for the chip-breakers and adjustment; but if the pressure-bars are spread out sufficient to clear two or three inches, which would be necessary in order to stick mouldings, the matcher-heads would be required to be carried farther back also, to give room to swing long cutters for deep mouldings: and the result is, the machine is so *spread out* that unless complicated and expensive devices are attached in order to keep the stuff from springing, good, straight, smooth planing and matching cannot be depended on.

If a machine of this class must be used for such purposes, it is far better to put on what is known as an independent beading and moulding attachment for that purpose.

But after all, it is poor economy to run a twenty-four-inch planer and matcher, with all the machinery attached, to stick small mouldings from one and one half to two inches wide, when a light sticker, costing but a few dollars in comparison to a planer, will do the same work with less power and to much better advantage.

In larger towns, where there is a prospect of more business, a different outfit is required. One good double surfacer to work up to twenty-four inches wide and six inches thick, either with or without matchers, should be the first machine selected. Then a narrow double-cylinder planer and matcher to work up to not less than 4 inches thick should be the next machine decided upon. If the twenty-four inch-machine is to have matchers attached so as to match and joint wide stuff, then the matcher need not plane over eight inches wide; but if the former machine is to be without matchers, then the latter should have sufficient width to plane and match 14 inches wide.

It is a well-known fact, and one that is recognized among experienced planing-mill men, that narrow machines for flooring are more convenient to handle, and economical to use, than wide ones; they are more compact, can be run at higher speed with the same power, and do smoother and finer work with a more rapid feed.

If the two machines just referred to are not considered sufficient, then the next most suitable machine to introduce is a heavy twelve-inch inside moulder. This class of machines, from their peculiar construction, are available for a greater variety of work than either of the planers; and by using a machine of this kind for small jobs of siding, pickets, shelving, and fence stuff, it enables the planers to be run constantly upon their regular legitimate work. And as every yard is expected to keep on hand a stock of mouldings to meet the requirements of the trade, this machine, when not otherwise engaged, can be profitably used for this purpose.

A resawing machine of sufficient capacity to cut fourteen inches wide should be added to this outfit, for splitting siding and panel stuff. In an ordinary mill there is very little occasion to resaw stuff over fourteen inches wide unless special orders for wide box stuff are to be filled: then, of course, a machine of sufficient capacity to meet the requirements of the business must be selected. But if there is much narrow stuff—such as six-inch siding—required, it would be economy to put in a small resaw expressly for that purpose. There is no economy in running a four-foot saw to cut six-inch stuff: it consumes more power; and as the cut is nearly square or at right angles with the grain, the work is not as smooth as if cut with a smaller saw working diagonally with it. Besides, the first cost of the large saw is at least four times as much as the small one, to say nothing about the extra time required to keep it in order.

A double-edging saw of the most approved pattern, with a swing cut-off saw and a couple of common saw-tables will complete the outfit, as far as the principal machines are concerned.

With such an outfit as we have just described a fair business may be done, and if properly managed and run economically it will be a profitable one provided there is sufficient business to keep the machines fairly busy.

So far I have said nothing with regard to the motive-power; but as most planing-mills are run by steam, we will assume that steam is to be the power. I believe there are more mistakes made in selecting the right sized engine and boiler for this purpose than in any other part of the outfit. In some way most people have conceived the idea that an immense power is required to run a planing-mill, and engines and boilers are often purchased of two or three times the power that is or ever will be required. Steam-engine builders, of course, would rather sell a large engine and boiler than a small one, and consequently encourage that idea.

While I have always advocated plenty of power, with a reasonable surplus for additional machinery, or other contingencies that may arise, I am not in favor of engines of sixty or seventy horse-power when thirty is all that will ever be required under ordinary circumstances. To illustrate this, I will cite two cases that came under my own observation.

One of my customers was about to start a planing-mill. After having arranged for his outfit,—which consisted of one medium-sized double-cylinder planer and matcher to work twenty-four inches wide, one thirty-two inch resaw, one twelve-inch four-sided inside moulder, a swing cut-off saw, and a rip-saw table, besides some other smaller articles,—I inquired what sized engine he intended to use, and whether he had made any arrange ment for it. He informed me that he partly contracted with a party for an engine with a cylinder 16×24 inches and a boiler to match. I asked him what his object was in putting in so large an engine. He replied that the parties with whom he was negotiating told him that planing-mill machinery required a great deal of power, and that he would find when he got started that the engine and boiler would be none too large to run the mill strong. I simply told him that if he wanted to burn up all the profits of his business that was about the best way he could do it; and when I recommended an engine ten by fifteen inches with a boiler to correspond, he thonght I was wild. I told him I thought I knew what I was talking about, and finally succeeded in convincing him that an engine and boiler of that size, with 60 pounds of steam and running 180 revolutions per minute, cutting off at three-quarter stroke, would be all the power he could use, with a fair surplus for contingencies, and that his machinery would make sufficient fuel to run it without using coal or wood. He changed his order under protest of the makers, and put it in.

The mill ran for five years before it burned, and during that time there were several more machines added to the outfit; and still he had all the power he needed, and was never able to burn all the fuel his machines furnished.

Another customer, contrary to my advice, put in an engine and boiler of something over twice the capacity of this, to run about the same outfit; and the result is, that he not only burns up all the fuel that his machines make, but is obliged to use from thirty to forty tons of coal per year in addition, and he realizes now that too much power is about as unprofitable as not quite enough.

There is no necessity for guesswork in these matters. At the present day manufacturers know or should know just what power is required to run each machine that they furnish; and those who intend starting a mill should first determine how many and what kind of machines they need, and then consult with the manufactures about the power required to run them; then, with a liberal allowance for shafting and other contingencies, select an engine and boiler suitable for the purpose. If this plan were adopted instead of depending entirely upon what the steam-engine builders say, there would be fewer mistakes made and less trouble and expense afterwards.

Before closing this chapter I will relate an incident that will show that people sometimes make mistakes in buying machinery as well as engines.

A few years ago a party in a certain locality, whom we will call Mr. A., concluded to put in a double-cylinder planer and matcher. Being a very close buyer, and not well posted as to the different kinds of machines that were advertised, he wrote to several firms for circulars and prices, and as a matter of course received numerous circulars and letters, all claiming to have the strongest, best, and cheapest machines in the market. Unfortunately for him, his experience with planers was very limited, and he was a good subject for the *cheap* ones to operate upon.

The circulars received from the firm of Good & Strong showed a first-class machine, weighing between 7000 and 8000 lbs., and for the class of work for which he intended to use it, was none too heavy. But the one received from Messrs. Blowhard & Co., which represented a machine of about one half the weight and about one half the price, but warranted to do the same work both in quantity and quality, attracted his attention. He first visited the factory of Good & Strong; and as they happened to have on hand a machine of that size Mr. Good carefully and honestly explained all the parts to him, and he seemed well pleased with the machine; but when the price, which was $900, was named, he informed Mr. Good that he could buy a machine that was warranted to do the same work for half that money, and pulled out Messrs. Blowhard & Co.'s letter and circular and showed them, at the same time saying that unless he could figure off about one half of that price he should try what he could do with the other parties.

Mr. Good quietly informed him that the machine referred to would not answer his purpose, and that if he purchased one of them for his business he would find it a dear purchase in the end; for no machine sufficiently strong to stand his work could be got up for that price.

But B. & Co. had offered to put it in on thirty days' trial, with the privilege of returning it at the end of that time if it did not prove satisfactory. Mr. Good, however, volunteered to advise him that if he was determined to try the cheap machine, not to pay any money on it until the thirty days had expired; for, in his opinion, the chances were that less than thirty days would satisfy him that he (Mr. Good) was telling the truth. Mr. A. thanked him for the suggestion, and left.

Arriving at the shop, Mr. Blowhard met him,—of course, all smiles,—and proceeded to show his machine, at the same time assuring him that it was all folly to pay the price that certain manufacturers were asking; that there was a great deal more iron in their machines than was necessary, and they were making big profits, and all he paid over a certain sum he was paying for their reputation; and if his machine was not all that he claimed it, he would not be willing to send it out on thirty days' trial, etc.

Mr. A. told him that he could ship the machine on those conditions, and as he had nothing but money to pay, that was ready at any time whenever he was satisfied that the machine was as he had represented. Before Mr. A. left, however, he stated to him that he had been disappointed in some of his collections and was short of funds just at that time, and if he would let him have $100 he would consider it a great favor. Mr. A., acting upon the hint given him by Mr. Good, declined to advance any money until he had given the machine a fair trial; and after giving the shipping directions started for home.

In a few days the machine arrived at the nearest station, which was sixteen miles from A.'s mill, and was hauled that distance by teams. The foreman, who was a man of considerable experience with planing-machines, looked it over and shook his head, but said nothing.

In due time it was set up, belted, and otherwise put in order. A lot of twelve-inch stock lumber that only required to be double surfaced was got in the mill. With the first board the hub of the driving-pulley on the back shaft burst, and that was taken to a blacksmith's shop and a couple of wrought-iron bands shrunk on, one on each end, and the machine started again. Two boards went through all right, but with the third one the pressure-plate over the bottom cylinder, which consisted of a cast-iron plate about four inches wide and one half inch thick, broke, and caught into the cylinder, when plate, cylinder, and all went kiting to the other end of the mill.

Mr. A., who had been watching the operation, at once ordered the machine loaded upon the wagon and carted back to the station, from which it was shipped back to Blowhard & Co. by *fast freight*. At the same time Mr. A. took the first train for Good & Strong's place, where he related the foregoing as his experience with cheap machines, and, finding they would not vary from the figures first given, concluded that it was better to pay a fair price and obtain a good machine.

It so happened that the same machine that he had previously examined was still on hand; he ordered it shipped at once, stating that the money was ready as soon as the machine was in satisfactory operation. Mr. Good informed him that he was in no trouble about that, and he could have thirty days to try it if he desired.

I have only to add, that the machine from Good & Strong started in the morning for the first time, and ran all day without any trouble, and turned out a good day's work, to the perfect satisfaction of Mr. A. This machine has now been in operation for a number of years, and the expenses for repairs have been but a trifle.

When everything was running smooth, Mr. A. figured up his account, which was as follows:

Railroad fare to Blowhard & Co. and back,	$5 00
Hotel expenses,	2 00
Freight,	9 00
Cartage to mill and back to station,	10 00
Second trip to Good & Strong's,	2 00
Blacksmith's bill for banding hub,	1 50
Handling and setting up,	4 00
	$33.50

Cr.

By planing three boards thirty-six feet at $2 per M.,	$0 07
Profit and loss,	33 43
	$33 50

CHAPTER XIX.

ADVICE TO OPERATORS—FEEDING CROOKED STUFF —SETTING THE GUIDES—THE USE OF SPRINGS NOT NECESSARY—MORE EXPERIENCE—CAUSES FOR LUMBER DRAWING FROM THE GUIDES, ETC.

THE careful study of this chapter by young men who are just starting out as foremen of a mill cannot but be of considerable importance. There is one point that does not seem to be as well understood by many as it should be, and that is, the proper adjustments required for the feeding of lumber to the machine. Many operators will complain that the lumber is inclined to work off from the guide, and say that it is impossible to keep it up unless the machine is furnished with a strong spring attached to the table in front of the rolls for that purpose. A spring is no detriment to a machine in case of very crooked lumber; but if the rolls and guides are set as they should be, there is not one board in twenty that will run off.

There are a number of causes that produce this effect: one is in not having the rolls set so as to bear equally upon both edges of the board. On wide machines, when the lumber is narrow and runs on one end of the rolls, the opposite end is apt to be from one half to one inch lower than the end resting on the board: this throws the pressure entirely upon the edge opposite to the guide, and as the whole draught is on this edge, the natural tendency is to *crawl* off, as the expression is, from the guide. If this condition were reversed, and the end of the roll opposite the guide set a little higher, so as to throw the greatest pressure on that side next to the guide, then the tendency would be to draw towards it. I am aware that where there is much variation in the thickness of the lumber that it is not always convenient to do so, especially with those in front of the machine; but with a little care in adjusting them they may be kept so that they will in most cases bear upon that part of the board.

Another cause is in not having the guides—especially the long one—set properly. It is well known to all experienced men, that if a board of even thickness on both edges be placed perfectly at right angles with the rolls it will pass through the machine straight, whether it has a guide or not; but if fed in at an angle, or out of square with the rolls, it will traverse the whole length of the roll and run against the uprights before it passes through. Now if the long guide in front of the rolls be set so as to throw the board at a small angle to the right, the tendency will be to draw that way; and if the angle be considerable, it will press against the guide with considerable force. The short guide behind the cylinder should also be carefully set in the same line with the long guide in front; otherwise the tendency will be to force the board out of its proper line, after it leaves the front rolls, and make a crook or bad spot in the matching.

On a machine of the ordinary length of frame, the long guide should be set from five eighths to three quarters of an inch out of a square line with the roll, measured on the extreme end opposite to it. Too much draught is not advisable, as it causes unnecessary wear by forcing the rolls hard against the opposite shoulders. I have known cases where the shoulders of the roller-shafts have worn into the box one quarter of an inch from this cause. The simplest and most convenient manner of setting the short guide behind the cylinder is, after the front guide is satisfactorily adjusted, select a straight board and run it about half way through the machine; then stop the feed, and set the short guide up to it. And in every case this will give a more satisfactory result than can be obtained with a straight-edge.

I once had an experience with a machine that was amusing to me but rather expensive to the proprietors. I furnished several machines for a new mill, and among the lot there was a twelve-inch double-cylinder planer and matcher. The machines were all fitted up in the most careful manner; and as they claimed to have engaged a man of large experiened to take charge of them and put them up, there was no necessity for sending a man from the factory for that purpose.

A week or two after the machines were shipped, I received a telegram in the usual language, *i.e.*, "the matcher don't work." I was well satisfied that the machine was all right and that the trouble was, "The man did not work."

However, I took the train the next morning and arrived at the station, and procured a horse and buggy and drove out to the mill, which was eight or ten miles in the country. I met one of the proprietors in the yard, and inquired what the trouble was. He replied he did not know: but one thing he did know, that they had spoiled 400 or 500 feet of lumber in trying to match, and the boards ran off so that some of them were only about half as wide at one end as the other; and that finally they had concluded to give it up and shut the machine down.

I accompanied him into the mill and asked the foreman if he had a square and monkey-wrench; he had, and got them. I put the square against the front roll and found the long guide about one inch out of square the wrong way. The guide had plenty of draught, but it was not the kind of draught required. I took the wrench, and loosened the nuts and set the guide back to its place, giving it about one half inch draught in its length, and requested him to start up. He did so, and every board after that hugged the guide so that there was no further use for the hand-spike that he had rigged up.

The proprietor at first was inclined to give the foreman a raking down for his ignorance; but I calmed him down by telling him that mistakes would sometimes happen in the best-regulated families.

He then invited me into his office and inquired how much my bill would be, as they had made such —— fools of themselves that it was no more than right that I should be paid for my time and expenses. I told him if he felt disposed to pay my expenses, I would accept that; but for the time, I would say nothing about it, as the joke on him was sufficient compensation.

Another cause for the lumber drawing away from the guide is in not having the pressure-bar behind the cylinder properly adjusted. If the end of the bar next to the guide presses hard on that edge of the board it is sure to draw off. While it is very essential, in order to make smooth work, that the pressure-bar should rest upon the whole width of the board, yet the side opposite to the guide may be a trifle closer without any detriment to the work or the machine, and helps to keep the board from drawing off without the use of levers or springs.

Where the machine is fed by a boy, who may be sometimes careless in placing the board against the guide, a light spring placed close to the front roll may be of advantage for that purpose; but if a machine is properly constructed, with the rolls square with each other and in line, then, if the guides are properly set, there is no use of the clumsy, heavy devices that are found attached to many planers for keeping up the boards, that require all the strength of the operator to push the lumber by them before entering between the rolls.

Some operators seem to think that everything must be screwed down as tight as possible in order to make smooth work, so that it requires all the power that is in the feed to force the lumber through. This is bad practice: the unnecessary pressure on the bed soon wears it away, so that it will require frequent planing off in order to be true enough to work all widths of lumber in a satisfactory manner. The slipping of the rolls when the pressure-bars are screwed down so tight also wears them away, so that they soon become imperfect; besides the extra wear and tear upon the gearing.

It is astonishing to note the difference in planing-machines, and, in fact, all other wood-working machinery, after a few months or years in use, when put in the hands of different operators. I could point out a large number of different machines, that have been in use five or six years in the hands of careful operators, which show but little wear and are practically as good as new; while others, which have run less than half that time, are, from careless usage and neglect, nearly used up.

If the bottom rolls are attended to and kept in line with the bed, there is no necessity for setting the pressure-bars so tight upon the stuff. If they rests upon the board just sufficient to keep it from vibrating with the cut, it is just as effective as it would be if the pressure were increased to a ton; and just as smooth work will be done, with much less wear and tear of the machine.

When the work comes out wavy, it is not always because the pressure-bar is not down tight; the fault may be in the cylinder-boxes or some other part of the machine. And the careful operator, who understands his business, will ascertain where the difficulty lies before he moves a screw; and then he will be sure to move the right one the first time.

CHAPTER XX.

ARTISTIC WOODWORK—IMPROVED MACHINES—CUTTING-TOOLS—IMPORTANCE OF A RUNNING BALANCE—HINTS FOR FITTING UP TOOLS—THEIR TEMPER—HARD AND SOFT CUTTERS CONSIDERED.

THE increased demand for artistic woodwork within a few years past has led to the introduction of many new, complicated, and useful machines.

Intricate carved work and irregular formed mouldings of the most elaborate kind, which were formerly worked by the slow and tedious process of hand-labor, are now produced by special machines invented expressly for the purpose, which not only performs the work more accurately and in less time, but materially decrease the cost of production.

This change has not only demanded more accurate and skilfully constructed machines, but a more skilful and intelligent class of mechanics to operate them successfully.

In mouldings especially, there is a great change, as compared with those stuck at the present time and those stuck a few years ago. Architects and builders are far more exacting now than they were at that time. Builders then were satisfied with mouldings if they were the correct shape and of an even thickness; and if the surface required smoothing down by the liberal use of sand-paper, or sometimes the moderate use of a hand-plane, there was nothing said, because it was the best they could get, and was far better than the laborious process of working them entirely by hand, as they had been accustomed to do in former years.

The competition among the manufacturers of those machines, and the desire of one to excel the other in the quality of their work, together with the increasing demand of the builders and architects for better machine-work and less hand-labor has brought the moulding-machine to such a state of perfection that the most intricate designs in mouldings are now made, both in hard and soft woods, so perfect and smooth that even the use of sandpaper is dispensed with. This of course requires mechanical skill, in order to keep those machines in a perfect state of adjustment and the cutting-tools in perfect order, as the quality of the work depends entirely upon these conditions.

The extra care required in fitting up a pair of cutters so that each may be the exact counterpart of the other and perform its part of the work, has led some operators into the pernicious practice of using one cutter, and counterbalancing it with a piece of iron, or another cutter of a different shape. If this was a practical thing, and the feed regulated accordingly, there is no doubt but just as smooth work might be done; but a cutter-head can never be balanced in that manner.

It is true a standing balance in this way may be obtained, *i.e.*, the head, when placed upon the balancing-bars, may remain at rest at any point, this showing a perfect standing balance. But there is a vast difference between this and a running balance; and unless the counterbalance is of the same weight and thickness in all of its parts, and every part of it revolving in the same circle, a running balance cannot be obtained.

It must be remembered that the centrifugal force of all bodies moving with different velocities in the same circle is proportioned as the square of their velocities; and a body revolving 100 revolutions per minute has 4 times the centrifugal strain as one moving 50. Again, the centrifugal force of two unequal bodies moving with unequal velocities, and at unequal distances from the centre are in the compound ratio of the quantity of matter, the square of their velocities, and their distance from the centre.

Now, in order to illustrate this, suppose two cutters, each weighing one pound, were attached to a head 5 inches in diameter, and describing a circle of that diameter at the rate of 3600 revolutions per minute: by the rules given in another chapter for calculating centrifugal force, the strain upon each side of the head would be equal to 77.55 pounds; but as a portion of each cutter must necessarily project beyond the diameter of the head to correspond to the depth of the moulding, the strain would be increased just in proportion to the weight of that part of the cutter, and its distance from the centre.

Now, suppose only one cutter were used, and, in place of the other, a piece of iron were fastened to the opposite side to form a balance. Although it may be of the same weight, and the head, when tested upon the balancing-bars, may show a perfect balance, yet when put in motion, those parts of the cutter which project beyond the head will present exactly the case just mentioned. There would be two unequal bodies moving with unequal velocities, and at different distances from the centre; and the difference in their centrifuga strain would be in the compound ratio of the quantity of matter, the square of their velocities, and their distance from the centre. So it is evident that a cutter-head cannot be balanced in that manner so as to run smooth and accurately.

Some operators claim this may be compensated for by making the counterbalance a trifle heavier than the cutter; but this is only guesswork, and the result cannot be relied upon: and the result is, the machine goes on rattling and jarring until every bolt and screw in it has worked loose. But this is not the worst feature of it. One side of the journal is constantly pressed against the box in its efforts to find its true centre of gravity, and soon that side becomes worn flat or egg-shaped, so that it will be impossible to run it until it is taken to the machine-shop and turned off. A few turnings so reduces the size that it soon becomes worthless.

If I were asked to express my opinion as to the best and surest way to use up a moulding-machine in the shortest time, I would recommend the use of one cutter, balanced with a piece of iron.

Notwithstanding some operators claim that it is a difficult matter to fit up two knives and keep them in shape so that each part will make the same cut, there is no difficulty whatever with proper facilities, except it may require more care.

A very convenient tool for this purpose may be constructed, with but little expense, that will easily enable one to accomplish this object. Get a couple of pieces of hard wood—one say about twelve inches long and the other six, and about one and a half inches thick and six or eight inches wide. After dressing them up perfectly straight and square, firmly attach the short piece to the long one, about three inches from one end, so that the two faces will make an angle of 45° to each other. On one side of the upright piece attach a guide parallel with its side and square with the bottom. Now if a piece of moulding the exact pattern of that which is to be stuck be bevelled on one end so as to fit closely to the bottom of the upright piece and fastened to the bottom of the form parallel with its edge, and then if the cutter is placed with its back against the upright and its side against the guide, when the edge is let to drop upon the pattern, and fitted to it and set accurately upon the head, there will be no danger but every part of one will be the exact counterpart of the other, and each perform its part of the work. With standard cutters, which are much used, the patterns should be cast of soft brass or babbitt-metal, to prevent them from becoming marred and losing their shape. As certain parts of all moulding-cutters wear away faster than others, they should always be dressed to this pattern in order to preserve their shape.

The proper temper for a moulding-cutter is a subject upon which there is a variety of opinions: some contending that they cannot be too hard as long as they stand; while others contend that very little temper is necessary.

Wishing to satisfy myself and be able to advise others understandingly, I made a series of experiments with cutters of different tempers. My experiments were conducted in the following manner:

A three-winged cutter-head was selected and balanced, with great care; three knives were prepared. One was given a light straw-color; the second a medium temper, so that it could be cut with a fine, sharp file; while the third was drawn down to a blue, with very little temper. These cutters were tested upon hard and soft woods; and in each case, after running a short time, the machine was stopped and the edge of each one examined with a strong magnifying-glass. The edge of each knife presented the same round appearance that all rotary cutters have after being used. If there was any difference at all, it appeared to be in favor of the knife with the medium temper. As each test gave the same results, and the advantages being in favor of the knife with the medium temper, the conclusions were that the fine, thin edge of the hard knife crumbled off, while the very soft one wore off; so that after running for one hour, neither had any advantage over the other.

With all the improved machinery at the present time, the practical wood-worker is frequently obliged to resort to his own ingenuity in order to get out some of the crooked and odd-shaped work that is required. With straight work, no matter how complicated, tools can always be adapted for the purpose. Where the work is to be done on the edge, no matter how crooked or complicated, the upright shaper—or variety moulding-machine, as it is sometimes called—is admirably adapted to this class of work and saves an immense amount of hand-labor.

In order to adapt it to all kinds of work, that portion of the spindles which projects above the table should be made so as to allow the cutter-heads to be as small as possible, in order to work in small circles. The cutters are bevelled upon both edges and fit into corresponding grooves in the collars; the lower one being stationary and revolves with the spindle, while the top one is loose and held down upon the cutters by means of a nut attached to the upper end of the spindle. The lower or stationary collar, as it is called, is made deep enough to allow the pattern to which the work is attached, to work against it. In this manner, it will be seen that, if a piece of stuff be fastened to this pattern by screws or otherwise, and kept constantly pressed against it as it is fed towards the cutters, it will follow the shape of the pattern and be worked to correspond with it.

With some of the earlier machines this difficulty presented itself.

If the spindles and collars were small enough to admit of working in very small circles, when heavier work required large collars and longer cutters they were found too light; so that heavy and light work could not be successfully run on the same machine.

This difficulty was met by some of the manufacturers and obviated by making the main part of the spindles, as far as the top of the upper bearing, sufficiently heavy to admit of being bored into and tapped; so that the part which projected above the table, and carried the collars and cutters, could be screwed into it. In that way, they were detachable, and any sized spindle or collar could be used.

This improvement had not only the advantage of allowing different-sized collars and spindles to be used upon the same machine, suitable for heavy or light work, but duplicate sets could be kept on hand; so that, instead of changing and setting the cutters for every different style of work which presented itself, and which required considerable time to adjust the cutters, one set with cutters attached could be readily removed and another substituted in a few minutes: and in this manner, heads and cutters for ordinary work could be kept constantly on hand all set up and ready for use.

The manner of raising and lowering the spindles so as to adjust the cutters to the work, in some of the earlier machines, was awkward and inconvenient. The workman was obliged to get under the table and screw them up from the bottom, which placed him in such a position that he could not see the work, and consequently had, in a great measure, to work by guess, which frequently involved the necessity of making several such attempts before the object was accomplished.

Now all first-class machines of this kind are provided with hand-wheels at the side, within easy reach of the workman, where, by means of bevel gears and screws, the spindles are readily adjusted to any point desired, the workman having his work and the cutters constantly in sight.

The best and most practical machines of this kind have two spindles working in opposite directions and furnished with duplicate cutters, so that, if a piece of circular work is being stuck, one half may be worked upon one head and the other upon the opposite one; thus enabling him to always work with the grain, and avoid slivering.

As some portions of the cutters for certain work necessarily project some distance beyond the collars, it requires considerable care in giving them a proper temper, so that they will stand. If too hard, they are liable to snap off; if too soft, they will be liable to bend: and in either case, they become useless until repaired or replaced by new ones. A good medium temper is indicated by heating the tool slowly over a clean fire or a piece of red hot-iron, after being hardened and scoured bright, until the color changes to dark purple with a slight tinge of green. This has been found to be the best temper for this class of tools. If the steel is of a good quality and has not been overheated, it will give it not only a fine cutting edge, but the greatest lateral strength.

When mouldings or other irregular shapes are to be stuck on the face of irregular or crooked pieces, the operation is more difficult. With segments of circles of not too small a radius the most convenient way is to work them upon a common sticker. This may be accomplished by first dressing the outside to the circle required, and then attaching to the table of a common sticker a reversed form corresponding to its shape, so that, instead of being fed by the rolls in a straight line, the work will be forced to conform to the circle of the guide, and follow it in a curved line, instead of a straight one. If the form, as it is called, is so placed that the radius of the circle which it represents is parallel with the line of the cutter-head, the moulding may be stuck with the same cutters, and will correspond in shape with those which are straight.

CHAPTER XXI.

FRICTION—THE LAWS WHICH GOVERN IT—SLIDING CONTACT—REVOLVING CONTACT—RESISTANCE ACCORDING TO WEIGHT, INDEPENDENT OF SURFACE IN CONTACT—ITS APPLICATION TO WOOD-WORKING MACHINERY.

FRICTION is the resistance arising from one surface coming in contact with another and rubbing against it. It is the only force in nature which is perfectly inert, its tendency being always to retard motion. In some respects, it may be considered as an obstruction to the power of man and an obstacle in carrying out mechanical designs. But, like every other force in nature, it may, if properly managed and understood, be turned to advantage. While it may be an obstacle in the running of machinery, yet it is the chief source, after all, of the general stability of everything that requires to remain in a state of rest. The experiments of Rennie and M. Morin—the latter under the direction of the French government—have demonstrated certain fixed laws which govern it: First, when two flat surfaces are pressed together without any lubricant, the amount of friction is in every case the same, and wholly independant of the extent of the surfaces in contact, so that, the force with which two surfaces are pressed together being the same, their friction is the same, whatever may be the extent of their surfaces in contact; second, similar bodies excite a greater degree of friction than dissimilar ones; third, with all hard substances, and within the limits of abrasion, friction is in proportion to the pressure, without regard to time or velocity.

All moving bodies in contact with each other are subject to three stages or conditions with regard to friction: One is a state where there is no lubricant used; another is a state in which a lubricant has been used but pressed out, so that the two surfaces come in intimate contact with each other; and, lastly, where the pressure is light and the lubricant is sufficient to keep the surfaces entirely apart by a stratum of the same interposed between them.

There is no rule established whereby the exact amount of loss by friction can be estimated, as the different kinds of metals used in the construction of machinery all produce different degrees of friction; besides, the great difference in the quality of the lubricant used often renders the loss double with one kind to what it would be with another. M. Morin estimates that, with suitable metals in contact, and with a good lubricator, the loss is from 20 to 25 per cent of the force by which the bodies are pressed together; or, in other words, if 2 sliding surfaces were pressed together with a force equal to 100 pounds, it would require from 20 to 25 pounds of power to put them in motion. And, according to the laws established by those tests, it would make no difference whether the bodies in contact have a surface of 1 square inch or 20; for with the same load and velocity, the friction would be the same, regardless of the surfaces in contact.

If a force or weight of 100 pounds be placed upon a surface containing 20 square inches, then the pressure would be only 5 pounds to the square inch and the friction upon each square inch of surface would only be the one twentieth of what it would be provided the whole 100 pounds were placed upon 1 square inch.

Again, if the 100 pounds were placed upon a surface containing but 1 square inch, this, having to sustain 20 times the load of the former, will consequently have to overcome 20 times the resistance by friction; and if moved at the same velocity, the liability of heat and abrasion would be increased 20 times. And when this condition commences, the loss by friction is indefinitely increased; besides, the surfaces are rapidly cut away and the parts soon destroyed.

In view of these facts, it is one of the most important duties of the designer of machinery—and one that cannot be neglected—to so apportion every wearing part of the machine, whether it be a sliding contact or a revolving one, that the surfaces in contact shall be in such proportion to the weight to be sustained that there will be no danger from heat and abrasion.

So far reference has only been made to such parts or devices which produce a reciprocating motion. But the same laws are applicable to revolving bodies; as, the journals and boxes upon which each part of a machine revolve.

There is, however, a slight difference in the conditions under which a sliding and a revolving surface may work, which may produce different results. In a sliding surface, the power is supposed to be applied in a direct line with the two surfaces in contact; so that in every case the power to move it is in proportion to the weight—the friction being the same, without regard to the extent of the surfaces in contact, or the velocity with which they are moved.

But this rule will not hold good with revolving shafts under the same conditions. For instance, if a shaft 2 inches in diameter, revolving in a bearing 6 inches long, sustaining a weight of 100 pounds, and driven by a 4-inch pulley making 1000 revolutions per minute, requires 25 pounds of the power applied to overcome the friction, no more power would be required to overcome the same friction if the speed were increased to 2000 revolutions. Neither would the friction be increased provided the box was increased to 10 or 12 inches in length; for it will be remembered "that with all hard substances within the limits of abrasion, friction is as the pressure, without regard to surface or velocity." Now, if the shaft were increased to 3 inches in diameter, with the same weight, and driven the same speed by the same sized pulley, the conditions would be changed, and more power required to overcome the resistance. While the frictional resistance would be the same in both cases unless the diameter of the pulley were increased in the same proportion, more resistance would be offered to the driving power in order to overcome the same friction and maintain the same speed. Hence, we say that with all revolving bodies, in order to comply with the laws of friction the power must in all cases be applied at the same proportional distance from the centre of that body.

Long bearings, then, require no more power to drive them with the same load than short ones, as long as the same diameter of shaft is retained. But if the diameter is increased in size, then a larger pulley will be required in order to retain the same leverage from the centre. This being the case, it is much more economical to use long bearings; for the more space or surface that the weight is applied to, the less the pressure upon any one place and the more surface to wear upon.

For instance, if a box has a superficial area of 8 square inches, and the weight of the body resting upon the shaft revolving therein is 160 pounds, it is evident that each square inch of surface between the shaft and the box will be pressed together with a force of 20 pounds. If the length of the box be increased with the same shaft so as to contain 16 square inches, then with the same load the two surfaces would be pressed together with a force of 10 pounds to the square inch instead of 20; and as only one half of the pressure is brought to bear upon each square inch of surface, and there being just twice the number of square inches to sustain the whole pressure, it is evident that, without any more loss by friction, the long box will wear just twice as long.

Again, if, instead of lengthening the bearing, we shorten it so as to diminish the area from 8 square inches to 4, then each square inch of surface would be required to sustain a pressure of 40 pounds; and if the same speed was maintained with the same load, the chances of injury arising from heat and abrasion would be increased in the same proportion.

Builders of machinery are becoming aware of this fact, as may be seen by the increased length of the journals both in shafting and nearly every kind of machinery where there is any amount of work required.

Wood-working machinery is of that class in which, under its conditions of work and in the most favorable circumstances, the wear and tear is greater than in any other class of machinery. It is not only the high rate of speed that it is required to run but the dust and grit with which most of the lumber is covered, is a constant source of annoyance to the most careful operator.

Wood-working machinery requires to be stronger and more accurate than any other class of work. A slow-running machine may have a number of little imperfections about it that may not manifest themselves for a long time; but with a planing-machine or moulder, if there is any imperfections in the bearings or boxes, they will manifest themselves in a very few minutes after it is started. Perfect bearings and long boxes are requisite to a well-running and durable machine; and that manufacturers as a class begin to understand this, is evidenced by the improved condition of the journals and boxes of all modern-made wood-working machinery.

CHAPTER XXII.

SHAFTING—ITS PROPORTIONATE SIZE AND SPEED—TORSIONAL STRENGTH CONSIDERED—METHOD OF TESTING—RULES FOR CALCULATING ITS STRENGTH—TABLE OF SIZE, VELOCITY, AND POWER.

THE necessary shafting and pulleys also enter into the items of planing-mill machinery, and much depends upon the selection of the most suitable size, the proper speed for utility and convenience, and the economy of power. Some are partial to large shafting and moderate speed, while others go to the opposite extreme of very small shafting and high speed. Now there is always a medium which is best adapted to all cases. A line of shafting for planing-mill purposes should always be adapted to its work, and in a great measure depend upon the size of the mill and the number of machines to be driven from it.

For planing-mill purposes, as all machines run at high speed, it is more economical to use a lighter shaft and run at high speed, as this enables each machine to take its power direct from the line without the use of large, cumbersome pulleys or intermediate counter-shafts, which are both expensive and objectionable.

It is a well-known fact that speed is power; and if a shaft 2 inches in diameter will safely transmit 15 horse-power at 100 revolutions per minute, that same shaft, if the speed were increased to 300 revolutions, would, with the same torsional strain, safely transmit about 43 horse-power.

Taking the first cost of heavy shafting and pulleys into consideration, the extra labor in handling, with the wear upon the boxes caused by that extra weight, and there is no doubt but medium-sized shafting with light pulleys running at a moderately high speed is the most economical in the end for planing-mill purposes.

Some object to high speed on account of the fear that it might shake the building; but in the present advanced state of mechanical science there is no more necessity for shaking the building with a shaft running 300 or 400 revolutions per minute than there would be at 100, providing the shafts are straight and true, and the pulleys well balanced; and no machinist at the present time who makes any pretensions to mechanical skill, or who values his reputation as such, would send out anything that was not so.

In selecting the shafting for a mill or factory, the millwright or mechanical engineer who may be intrusted with that part should have a thorough knowledge of the torsional strength of iron in order to make a proper and judicious selection. The amount of twisting strain that can be sustained by a shaft of a given size without permanent injury or displacement of the particles composing it have been variously estimated.

Trautwine says, "To compute the size shaft to transmit a given number of horse-powers, multiply the number of horse-powers to be transmitted by 300 and divide the product by the number of revolutions per minute, and the cube root of this quotient will equal the size of the shaft."

According to this rule, then, in order to transmit 50 horse power from a shaft making 125 revolutions per minute, it would require a diameter of $4\frac{93}{100}$ inches, thus: $300 \times 50 \div 125 = 120$; the cube root of which is 4.93 inches.

By the rule given by Scribner, the same shaft would require a diameter of $4\frac{1}{2}$ inches. He says: "This rule comes from the highest authority and will give perfectly safe results."

There is no question, so far as the safety is concerned, for by this same rule a shaft $2\frac{1}{2}$ inches in diameter would not be able to transmit but a trifle over 15 horse-power at a speed of 100 revolutions per minute. It would be a difficult matter to make any practical machinist or millwright, in the present state of the art, believe that this rule is anywhere near correct, or that a shaft $2\frac{1}{2}$ inches in diameter, at 100 revolutions per minute is not able to transmit with perfect safety from 25 to 30 horse-power.

Being fully satisfied that those rules were not reliable, and desiring to arrive at some correct basis, a series of tests were instituted by the author, which were conducted in the following manner:

Several pieces of iron were cut from the same bar, and a space 12 inches long turned on each one 1 inch in diameter. One end was secured in a strong vice, while the other was supported upon a centre so as to allow it to move freely. To this end was attached a lever, having a notch cut in it just 12 inches from the centre of the shaft. A suitable box for holding the weights was suspended from the lever at the notch by a bail provided for the purpose. The weight of the box being known, the weights were carefully placed in the box so as not to produce a shock, and the deflection of the lever carefully noted at each increase of the weight until the bar began to show a permanent set. By means of a cord and small pulley attached to the floor above, the box could be gently raised so as to relieve it from the weights, and note the deflections of the lever. With 400 pounds the deflection of the lever at the notch was $1\frac{1}{2}$ inches. But when relieved from the weight it returned to its original position. The load was then increased in the same manner to 420 pounds. The deflection of the lever was then nearly 2 inches, and when relieved of the load again it showed a permanent set in the bar of 4°. Tests were then made with other bars of the same size and length by applying the load suddenly. It was found that when 100 pounds were dropped suddenly upon it, the same deflection of the lever was shown that 400 pounds produced when let down carefully and without any shock. Over 100 pounds applied with a shock produced a permanent set in the bar. From these tests we arrived at the following facts:

That where shafting is subjected to sudden shocks, as all shafting is liable to be by the throwing on of heavy belts in starting machines, one fourth of its ultimate strength is all that can be safely relied upon in practical use. To reduce this to foot-pounds, or to a given number of pounds moved at the rate of 1 foot per minute, suppose the lever 1 foot long to represent a pulley of 1 foot radius or 2 feet in diameter; and suppose 1 revolution per minute is taken for the unit of speed. Now the circumference of a pulley 2 feet in diameter is near enough to 6 feet in circumference for all practical purposes, so that the 100 pounds at each revolution would be carried through a space equal to 6 feet per minute, which would be equal to 600 pounds carried through a space equal to 1 foot in the same time. Thus we find that a shaft 1 inch in diameter revolving at the rate of 1 revolution per minute will transmit 600 pounds per minute, no matter what the distance may be from the centre at which the power is applied in order to communicate it.

For example, if the power be applied to a pulley 4 feet in diameter instead of 2, at each revolution of the shaft the load, whatever it may be, will be carried through double the space in the same time, and consequently requires but one half the force to produce the same effect. Therefore we divide this 600 pounds by the circumference of the pulley to find the force to be applied once every minute to obtain that result. Thus if the pulley were 12 feet in circumference,

$$600 \div 12 = 50 \text{ pounds.}$$

So that 50 pounds applied to a pulley 4 feet in diameter making 1 revolution is equal to 100 pounds applied to a pulley 2 feet in diameter at the same speed.

Again, if it were required to find the number of revolutions per minute that a shaft 1 inch in diameter should make to transmit a given power, divide the number of pounds contained in that power by the number of pounds which the shaft is capable of transmitting at 1 revolution per minute.

If it be required to determine the number of revolutions per minute that a shaft 1 inch in diameter should make in order to transmit 2 horse-power, take the value of 2 horse-power and divide it by 600; thus:

$$33000 \times 2 = 66000 \div 600 = 110 \text{ revolutions.}$$

When the speed of a shaft 1 inch in diameter is given, to find its power multiply the speed of the shaft by its size and by 600, and divide by the value of 1 horse-power.

Example: what power will be transmitted from a shaft 1 inch in diameter revolving at the rate of 110 revolutions per minute?

$$1 \times 110 \times 600 \div 33000 = 2 \text{ horse-power.}$$

The foregoing examples and rules are applicable to shafts 1 inch in diameter exclusively; but now to apply the same rule to other sizes other conditions must be complied with. It is well-known to mechanical experts that the torsional strength of all round bars of iron of different diameters are to each other as the cube of their respective diameters; but as the cube of 1 is 1, there is no necessity for a proportional statement, and all that is required to apply the foregoing rules is to use the cube of the diameter instead of the real diameter. Hence, to find the power of any sized shaft when the size and speed is given, multiply the cube of the diameter by the number of revolutious per minute and that product by 600, and divide by the value of 1 horse-power.

Example: What power may be transmitted from a shaft 2 inches in diameter at a speed of 110 revolutions per minute?

First, the cube of 2 is 8; then

$$8 \times 110 \times 600 = 528000 \div 33000 = 16.3 \text{ horse-power.}$$

When the diameter of the shaft and the power required are given to find its speed, first multiply the given power by the value of 1 horse-power to obtain the number of foot pounds required per minute, and then divide by 600, (the unit of foot-pounds for 1 inch), and the cube of the diameter of the shaft the quotient will equal the number of revolutions per minute.

Example: At what speed should a shaft 2 inches in diameter run in order to transmit 16 horse-power?

First, 16 × 33000 = 48000 foot-pounds per minute required. Then as 600 is the unit for 1 inch, 48000 ÷ 600 = 880 pounds, the strength of the shaft, or the number of foot-pounds which it is able to safely transmit. Now if the last number be divided by the cube of the diameter of the shaft the quotent will equal the speed—880 ÷ 8 = 110 revolutions.

When the power and speed are given to find the size of the shaft, first asertain the number of foot-pounds which are required in order to obtain that power. This is obtained by multiplying the given power by the value of 1 horse-power; then this product divided by the number of revolutions per minute given represents the number of foot-pounds that may be transmitted at each revolution, and as 600 pounds to the revolution is the unit, by dividing by this number we obtain the cube of the diameter of a shaft capable of transmitting that power at the given rate of speed the cube root of which is the diameter required.

Example: The diameter of a shaft is required which will transmit 16 horse-power at a speed of 100 revolutions per minute: 16 × 33000 = 528000 ÷ 110 = 4800 ÷ 600 = 8 cube root of 8 = 2 inches.

From the foregoing tests and examination of this subject, we have been able to formulate the following rules:

CASE 1. When the diameter of a shaft is given, and the power it is required to transmit to find its speed.

Rule: Multiply the given power by 33000 and divide that product by 600; this quotient divided by the cube of the diameter of the shaft will equal the speed in revolutions per minute.

CASE 2. When the diameter and speed of a shaft are given to find its power.

Rule: Multiply the cube of the diameter by 600, and that product by the number of revolutions per minute and divide by 33000: the quotient will equal the number of horse-power.

CASE 3. When the power required and the speed of a shaft given, to find its diameter.

Rule: Multiply the given power by 33000; divide this product by 600 and the speed of the shaft in revolutions per minute. The cube root of this quotient will equal the diameter.

To familiarize the reader with the foregoing rules, the following promiscuous examples are given:

What power may be transmitted from a shaft $2\frac{1}{2}$ inches in diameter running at a speed of 300 revolutions per minute? The cube of $2\frac{1}{2}$ is 15.6; then $600 \times 15.6 \times 300 \div 33000 = 85$ horse-power.

Required the power that may be transmitted from a shaft 3 inches in diameter at 150 revolutions per minute. $3 \times 3 \times 3 = 27$ (the cube of the diameter); then $27 \times 600 \times 150 \div 33000 = 73.63$ horse-power.

How many revolutions per minute must a shaft 3 inches in diameter make in order to transmit 90 horse-power? $90 \times 33000 \div 600 \div 27 = 183.33$ revolutions.

How many revolutions per minute should a shaft 2 inches in diameter make in order to transmit 25 horse-power? $25 \times 33000 \div 600 \div 8 = 171.87$ revolutions.

What is the required diameter of a shaft that will transmit 180 horse-power a speed of 120 revolutions per minute? $180 + 33000 \div 600 \div 120 = 82.5$, the cube root of which is 4 35 inches.

What sized shaft would be required to transmit forty-eight horse-power at three hundred and thirty revolutions per minute? $48 \times 33000 \div 600 \div 330 = 8$ cube root of $8 = 2$ inches.

In the application of the foregoing rules, torsional strength is all that has been taken into consideration. There are, however, other things to be taken into consideration in connection with this subject, before deciding upon the most suitable sized shafting for a mill.

It often becomes necessary to place a pulley or gear that may be required to transmit a large portion of the power to another shaft, and that pulley or gear may be required to be placed in the centre of the shaft between the bearings; and while the torsional strength may be amply sufficient to perform the work, the transverse strength may not be sufficient to prevent it from springing sidewise. This, however, may always be remedied by either using a larger piece of shaft at this particular place, or by adding another bearing close to the pulley or gear, as the case may be: but the latter is always preferable when it can be conveniently done.

One of the mistakes often made in arranging for shafting is a proper distance between the bearings. Cases are often met with in the same mill where there may be two or three lines upon different floors, each of different size, yet the distance from centre to centre of the bearings are all about the same. This is not good practice; for while the sizes of the different lines may be in good proportions according to the amount of labor they are required to perform, the distance from centre to centre should also be in proportion to the size: otherwise they will be deficient in laterall strength.

The transverse strength of all-round bars of iron of different sizes, but of the same length, is in proportion as the square of their diameters; consequently shafts of smaller diameter require less distance between bearings, in order to retain their lateral strength, than larger ones. The most practical rule that can be adopted and coincide with this is to take three times the diameter of the shaft in inches for the same number of feet between the centres of the bearings.

Thus a shaft three inches in diameter would require nine feet from centre to centre of the bearings, while one of two inches diameter would require six feet—and so on. The proper length of bearing is another consideration, and in ordinary practice should not be less than three diameters of the shaft. In special cases, where there is an unusual stress, the length may be increased to four diameters.

A large amount of power is frequently lost in many mills by the use of imperfect shafting. To run well and economize power, a line shaft should be perfectly straight and true; all pulleys (and gears, if any are used) should be perfectly balanced, so that when the whole is put up and the bearings oiled, a line 100 feet long should be readily turned by hand by taking hold of one of the pulleys. But if put up imperfect, out of line with pulleys, not well balanced, several horse-power will be required to overcome the frictional resistance.

The following table shows the number of horse-power that may be safely transmitted by shafts from one inch to six inches inclusive, at speeds from 100 to 300 revolutions per minute, compiled from practical tests by the author.

TABLE I.

Number of Revolutions.	100	125	150	175	200	225	250	275	300
Diameter of shaft in inches.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.
1	1.81	2.27	2.72	3.18	3.63	4.09	4.54	5.00	5.45
1⅛	2.58	3.22	3.87	4.51	5.16	5.80	6.45	7.10	7.74
1¼	3.54	4.43	5.31	6.20	7 09	7.97	8.86	9.74	10.39
1⅜	4.72	5.90	7.09	8.27	9.45	10.63	11.81	13.00	14.18
1½	6.12	7.66	9.19	10.72	12.26	13.79	15.32	16.85	18.39
1⅝	7.80	9.45	11.70	13.65	15.60	17.55	19.50	21.44	23.40
1¾	9.74	12.17	14.61	17.18	19.48	21.91	24.35	26.78	29.22
1⅞	12.53	15.62	18.75	21.87	25.00	28.12	31.25	34.37	37.50
2	14.50	18.12	21.75	25.37	29.00	32.62	36.25	39.87	43.50
2⅛	17.40	21.75	26.10	30.45	34.80	39.15	43.50	47.85	52.20
2¼	20.70	25.87	31.05	36.22	41.40	46.53	51.75	56.92	62.10
2⅜	24.30	30.37	36.45	42.52	48.60	54.67	60.75	66.82	72.90
2½	28.40	35.50	42.60	49.70	56.80	63.90	71.00	78.10	85.20
2⅝	32.80	41.00	49.20	57.40	65.60	73.80	82.00	90.20	98.40
2¾	27.80	47.25	56.70	66.15	75.60	85.05	94.50	103.95	113.40
2⅞	43.20	54.00	64.80	75.60	86.40	97.20	108.00	116.80	129.60
3	49.00	61.25	73.50	85.75	98.00	110.25	122.50	134.75	147.00
3¼	62.40	77.90	93.60	109.20	124.80	140.40	156.00	171.60	182.20
3½	77.90	97.37	116.85	135.32	155.80	175.27	194.75	214.22	233.70
3¾	95.80	119.75	143.70	167.65	191.60	215.55	239.50	263.45	284.40
4	116.30	145.37	174.45	203.52	232.60	216.67	290.75	319.82	348.90
4¼	139.50	174.37	209.25	244.12	279.00	313.87	348.75	388.62	418.50
4½	165.60	207.00	248.56	289.80	331.20	372.60	414.00	455.40	496.80
4¾	194.80	243.50	291.20	340.80	389.60	438.30	487.00	535.70	584.40
5	227.20	284.00	340.80	397.60	454.40	511.20	568.00	640.80	681.60
5½	302.00	377.50	453.00	528.50	604.00	679.50	755.00	830.50	906.00
6	392.00	490.00	588.0	686.0	784.0	892.0	980.0	1078.0	1176.0

CHAPTER XXIII.

THE SELECTION OF BELTING—THE IMPORTANCE OF THE MILL BEING PROPERLY BELTED—LEATHER BELTING BEST ADAPTED FOR THIS PURPOSE—RULES FOR CALCULATING THEIR POWER—HINTS FOR THEIR CARE AND MANAGEMENT—OILS NOT SUITABLE—DOUBLE BELTS; TABLE SHOWING THEIR POWER.

MUCH of the comfort and economy in the management of planing-mill machinery arises from having a mill properly belted. With the high speed at which they are required to run, and the liability of becoming saturated more or less with oil and often subjected to chafing more or less, leather has been found the only practical material that should be used for this purpose. Oak-tanned leather belts, cut as near the back of the hide as possible, should be selected; they should have short laps and be strong, and of even thickness and well put together.

While almost everything pertaining to machinery has fixed rules whereby the strength and power may be calculated, it is a fact that there are no reliable rules whereby the power of a leather belt may be calculated with any degree of certainty. We would not wish to be understood as saying that there are no rules: on the contrary, there are plenty of them. Every belt-manufacturer who publishes a catalogue of his work has a set of rules of his own; but the trouble is, no two agree upon the same thing: according to one, a belt six inches wide, with a given speed and stress, should transmit eight horse-power; while another would give to the same belt, under the same condition, ten. We have endeavored to harmonize these rules, and, if possible, discover some true bases to work upon, but confess we have failed to do so. Being convinced that the power of a belt is simply a question of friction between the under side of the belt and the face of the pulley, produced by the tension or stress upon it, it would seem that all that was required was to devise some plan whereby, with a certain stress and under certain conditions, that friction could be measured and then reduced to some fixed rules that would be at least approximately correct.

For the purpose of making these tests, two iron pulleys twenty inches in diameter and of 4-inch face were selected. These, after being bored and turned both to the same size, were balanced and fitted upon a shaft and secured by keys. This shaft was then suspended upon centres prepared for the purpose, so as to be free to turn with the least amount of friction. One end of a strap was fastened to the face of one pulley, and passed around it, while to the other end a bucket was attached and suspended to receive whatever weight might be required. A piece of leather belt of the average thickness, one inch wide, was secured to the floor by one end, while the other was passed over the pulley in the opposite direction, so as to embrace just one half of the circumference, and a similar bucket attached to it. One hundred pounds, including the weight of the bucket, was then applied. Weights were then placed in the first-mentioned bucket until the friction of the belt was overcome and the pulley began to slip under it. This was so regulated by small weights that after repeated trials the descent of the bucket would average one foot per minute. This was quite a delicate matter, and only accomplished after repeated trials. The first bucket, containing the weights, was then detached and weighed, with its contents, and found to equal 40 pounds. A piece of 2-inch belting was then substituted for the 1-inch, and, with the same weights, gave the same results. The weight in the first bucket was then increased to 200 pounds and the friction arising from the second overcome, as before, by adding weights; 80 pounds were then required to produce the same result. Tests were then made in the same manner with 3 and 4-inch belts, and all gave the same results, viz.: that the frictional power of a leather belt embracing one half of the circumference of a cast-iron pulley is equal to $\frac{40}{100}$ of its stress, regardless of its width. Tests were also made with new belts which had been used but a few days, as well as those which were old and filled with grease. The new ones, when first applied, gave a trifle less than 40 per cent; those which had been used a few days gave a small fraction over, while the old ones showed considerable over that amount, but broke so frequently that their real frictional value could not be obtained with any degree of certainty.

Those tests established this fact: that if the frictional power of a leather belt moving at the rate of 1 foot per minute is 40 per cent of the stress, with a stress of 100 pounds, moving at the rate of 1 foot per minute, 40 pounds of efficient force is all that can be realized from it. But if the stress be increased to 400 pounds and still moving at the same rate, 160 pounds of useful effect will be returned.

Again, if the stress remains the same and the speed be increased to 2 feet per minute, then the power returned in frictional force per minute will be doubled. Hence, with equal stress, the frictional power per minute increases directly as the speed, and with equal speed it increases directly as the stress. From these two propositions we are able to adduce the following rule:

When the stress is known, to find the power multiply the speed of the belt in feet per minute by .40 of the stress in pounds, and divide by 33,000.

Example: Assume the stress upon a leather belt to be 600 pounds and the speed 2,000 feet per minute. First, 40 per cent of 600 is 240; then $240 \times 2{,}000 = 480{,}000$ and $480{,}000 \div 33{,}000 = 14.28$ horse-power.

Now, this power may be obtained from a belt 8 inches wide, or from one 12, provided the stress is the same, and the belt strong enough to withstand it; for the resistance of belts to slipping, with equal stress. is independent of their width, and there is no advantage, in a frictional point of view, derived from increasing the width beyond that which is required to resist the tension without material injury. It must not be assumed, however, that, because a belt 1 inch wide may sustain a weight of 350 pounds, it would be good practice to run a belt of that width at any such tension, for the reason that the fibres of the leather would soon become detached from each other by the continued strain, and thereby become worthless.

Durability must always be taken into consideration, as well as quantity of work to be performed in a given time. A small horse may be compelled for a short time to draw a heavy load: but by constantly overtaxing his abilities, his enegies soon become exhausted and render him worthless; while a much heavier and stronger animal would perform the same work from day to day without material injury.

So with a belt: the wider it is with the same stress the less the strain upon each inch in width. If 1200 pounds stress were put upon a six-inch belt, each inch would be required to sustain 200 pounds; whereas, if the whole stress was 600 pounds, then there would only be 100pounds to be sustained by each inch in width; and it needs no argument to show that with a stress of 60 pounds or 100 pounds to the inch, that the belt would last much longer than it would with double that strain. Therefore within reasonable bounds the wider the belt the longer it will last.

There is one difficulty that presents itself in calculating the power of a belt, and that is to determine just what the tension is, or what it should be. Some claim that the average tension should be 200 pounds to the inch in width, but it is very doubtful whether driving, belts as a rule are ever submitted to any such tension, or more than half of it. If so, a belt 12 inches wide should be constantly submitted to a strain equal to 2,400 pounds, or nearly $1\frac{1}{4}$ tons weight: it is a question of considerable doubt whether it would stand a weight of that amount suspended from one end of it for any length of time without permanent injury to the fibres of the leather.

From extensive observation I am led to believe that the average stress upon driving belts as a rule does not exceed 100 pounds to the inch in width. It is true that when running a large portion of the stress is upon the driving side; but even then, except under peculiar conditions, I doubt whether a strain of 200 pounds to the inch in width is ever attained.

The stress of a belt may be approximately obtained, however, by calculating the stress required to give a frictional force equal to a given power, and by assuming a certain width; then if the belt, when put to use, performs the work in a satisfactory manner without slipping, it is reasonable to suppose that the tension is not less than a given number of pounds.

Practical experience has proved that if a belt will perform the required work when running slack, it will last much longer than one of less width with double the tension. Extremes in this as well as in every other case should be avoided. If a belt is run so slack that it is constantly flapping about, the sudden jerks are not only detrimental to the belt itself but to the machinery and shafting attached—especially so with planing-mill machinery.

In selecting a driving-belt, and determining its width, there are always certain conditions to be considered and complied with: First, the amount of power to be transmitted; second, the speed of the line shaft and size of the pulley required. This, when the power is steam, must be determined by the speed of the engine and size of the band-wheel. When these points are settled, the width of the belt may be determined according to the diameter of the pulley: a small pulley at the same speed requires a wider belt in order to obtain the necessary frictional surface.

In ordinary practice it is well to run the line-shaft about 300 revolutions per minute in order to avoid loading it down with large heavy pulleys, and also to enable those machines which have counter-shafts attached to be driven direct from the line, thereby avoiding the use of intermediate shafts as far as possible. At 300 revolutions per minute, with good bearings and well balanced pulleys, there is no objection to that speed, or even more, if necessary.

Suppose after all these points are settled the result should be as follows: An engine of 60 horse-power is required, the band-wheel of which is 8 feet in diameter, and is required to make 150 revolutions per minute. To accommodate the greater number of machines, the line-shaft is required to run 300. From this data the diameter of the driven pulley for the line-shaft and width of the belt must be calculated. As the size of the main pulley must be in proportion to the band-wheel, as its speed we have this proportion: 300 : 150 :: 8 : 4; consequently the diameter of the main pulley must be 4 feet.

Now as the circumference is equal to the diameter multiplied by 3.1416, in order to find the speed of the belt in feet per minute the diameter must be multiplied by this number, and the speed or number of revolutions per minute; for it is evident that the belt must pass over the whole circumference of the pulley 300 times per minute in order to make 300 revolutions in that time; then $4 \times 3.1416 \times 300 = 3769.92$ feet per minute.

Now the tension of the belt to produce a frictional force upon the face of the pulley sufficient to equal 60 horse-power must be computed. As the unit for 1 horse-power is a force equal to 33,000 pounds, moved at the rate of 1 foot per minute, 60 horse-power must be multiplied by that number; then $33{,}000 \times 60 = 1{,}980{,}000$ pounds of frictional force, which must be applied once in every minute.

The stress upon the belt, as we have already found, is proportional to the frictional power as 100 is to 40; so that in order to find that stress we say 40 : 100 :: 1,950,000 : 4,950,000 pounds : then $4{,}950{,}000 \div 376.992$ (the speed of the belt in feet per minute) $= 1313$ pounds, which must be constantly applied; or, in other words, 1313 pounds is the whole stress that is constantly applied to the belt, and without any allowance for extra shocks in starting, etc., a belt $13\frac{1}{2}$ inches wide would give that power by the foregoing rules already given. But to allow for this and other contingencies which are liable to arise, one of 16 inches would be preferable.

In selecting belts, those of even thickness, with moderately short laps, and well riveted, should be chosen. A good way to test the quality of the leather is to bend it short towards the flesh side. If the material is poor or been injured in the process of tanning, it will show fine cracks when submitted to this test. If the material is good, it should be soft and pliable and bend short without showing any signs of cracks in the grain.

Some manufacturers recommend running the grain side next to the pulley, thereby claiming a much greater percentage of power with the same stress.

While there is no doubt that this is the proper way to run a belt, the tests made do not warrant any such results.

The reason for running the grain side next to the pulley is, there is more strength in the flesh side than there is in the grain; and that part of the belt which possesses the greatest tensile strength should be subjected to the least wear. This may be demonstrated by splitting a piece of belt leather exactly in the centre and submitting each part to a breaking strain, when it will be found that the part next to the flesh side will require nearly double the strain to part it as the other. So that a belt run with the grain side next to the pulley, when worn down to nearly one half of its original thickness will retain more than three quarters of its original strength, unless otherwise injured; while the same belt run with the flesh side to the pulley will give out and break long before it reaches that condition.

Another reason is that the best of belts, and those that are soft and pliable when new, after being used and exposed to the fine dust that is constantly settling upon them, soon absorb the oil, rendering them hard and dry; then if run over small pulleys with the grain side out, they become filled with fine cracks, which materially impair their strength.

When belts become hard and dry, they are not only more liable to crack, but as they do not adhere to the pulleys, and are constantly slipping more or less, the heat generated by the friction burns them so as to impair their strength, and in a short time renders them worthless. When such is the case, it is the common practice in many mills to pour on any kind of oil, rub on soap and rosin, or, in fact, anything convenient to prevent them from slipping. This is all wrong. If the belt is too slack, stop and take it up; for it is much cheaper to stop for half an hour than to spoil a belt worth forty or fifty dollars.

Lubricating-oils such as are in general use contain more or less mixtures of hydro-carbon, which is detrimental to leather. Lard-oil is also injurious, from the fact that it contains a large percentage of margaric acid. There are also many patented articles under various names of *stuffing*, for softening and preserving belts, which are advertised and hawked about; and if mill-owners would believe one-half the stories which are told by drummers for those articles, they would believe that a belt would never get old, wear out or break as long as they continued the use of their preparation.

Now, the basis of nearly all of these compounds—all, so far as they have been examined is—either petroleum in some of its numerous forms, or some other hydro-carbon mixed with neatsfoot oil or something worse, and totally unfit for this purpose. Tallow seems to be the only material that is natural to leather, but should never be applied to a belt when dry and covered with dust, for this reason: The solid fats of all animals are composed of three elements, viz; stearine, margarine, and oleine.

Margarine contains a large percentage of margaric acid, which must be kept out of the belt as far as possible. The proper manner to treat a belt when it becomes hard and dry, and to exclude the greater portion of the margarine, is to take it off and lay it upon a clean floor ; then, with soap and warm water, thoroughly cleanse it, and, if necessary, scrape it until the surface on both sides is perfectly clean ; then prepare some clean tallow by melting it, and, with a brush, apply a thick coat upon the flesh side while it is just soft enough to spread well and while the belt is wet, and then leave it until it becomes perfectly dry. The stearine and margarine are both insoluble in water, and will not enter the pores of the leather while it is wet.

Margarine has a greater affinity for stearine than it has for oleine ; consequently, it remains on the outside and becomes hard before the leather becomes dry enough to absorb it ; while the olein, which has a greater affinity for the leather, seperates from the other ingredients, and, as the water evaporates gradually, assumes its place, leaving the other two on the outside in the form of a white substance much harder than tallow, which may be readily scraped off. Belts treated in this manner about once in six months will be as soft and pliable as new, and retain their strength until worn out.

Many object to this process of taking off their belts and wetting them, because they shrink up so that it requires an unreasonable tension to replace them. This may be avoided by fastening the belt to the floor by means of clamps before washing it.

To formulate rules for determining the length of a belt may to some appear quite superfluous. This may be the case in many instances—perhaps so in the majority which come within the range of ordinary practice.

When everything in the mill is favorable,—the counter-shafts, if any, all up, and the pulleys on the line-shaft, together with all the machines that are to be driven from it in their respective places, then with a good tape-line, the length of each belt, whether crossed or straight, may be easily obtained by measurement.

This condition of things, however, does not always exist. It is sometimes necessary to determine the length of some of the belts, especially the large drivers, before the shafts and pulleys are in position. The distance between centres, and the size of the pulleys may be obtained from the drawings. Much time may be saved in this way, especially if the belts are made to order and shipped from a distance.

Crossed belts should be avoided as far as possible, especially if there is considerable difference in the diameters of the pulleys and the distance between centres limited to a short space. In such cases the cross will occur so near the small pulley that the tendency to run off will require the constant use of a belt-shifter or some other device to keep it on the pulley, The chafing upon this, with the friction upon the belt where they cross each other nearly edgewise, under such conditions will soon destroy it.

When pulleys are nearly of the same size and the distance between centres considerable, the cross will occur nearer the centre of the space between them, and the two surfaces cross each other nearly flatwise and with but little friction. Under such conditions, a cross-belt is not so objectionable.

The rule for calculating the length of an open belt when the distance between centres and the size of the pulleys are known, is very simple :

To twice the distance between the centres, add one half the circumference of each pulley, with three times the thickness of the belt.

Example : Suppose the distance between the centres of two shafts is 14 feet, the diameter of one pulley is 8 feet and the other 4, and the thickness of the belt is $\frac{1}{4}$ inch. Then one half the circumference of the 8-foot pulley is 12.5664 feet. One half the circumference of the 4-foot pulley is 6.2834 feet. Three times the thickness of the belt is $\frac{3}{4}$ inch, or .0625 feet ; then $28 + 12.5664 + 6.2834 + .0625 = 46$ feet $10\frac{15}{16}$ inches.

To find the length of a cross-belt, the rule is more complex, and when the pulleys are in position and can be conveniently reached, it is much easier to determine their length by the tape line. If not, the following rules are applicable and will give correct results.

First, the distance from the centre of each pulley to the centre of the point where they will cross, must be obtained. If both pulleys should happen to be the same diameter, the cross will occur exactly in the centre of the space between them. If not, then that point will be in proportion to their respective diameters, and may be found by the following rule :

Divide the diameter of the larger pulley by that of the smaller, and add one to the quotient. This will represent the number of parts into which the distance between centres is supposed to be divided into. Then as the whole number of parts is to the number of parts taken by the larger pulley, so is the whole distance between the centres to the point where the cross will occur.

Example: A pulley 8 feet in diameter is to drive one of 4 with a cross-belt $\frac{1}{4}$ inch thick, the distance between centres being 14 feet; required, the distance to the point where they will cross, and the whole length of the belt.

First, find the point where they will cross, by the foregoing rule: $8 \div 4 = 2 + 1 = 3$. This represents that the 14 feet are supposed to be divided into three parts; and as the diameter of the small pulley is contained in that of the larger one twice, it shows that two parts of the three must be taken by it: then, $3 : 2 :: 14 : 9' 4''$ Now as the whole distance is 14 feet, and the large pulley requires 9 feet 4 inches, the distance from this point to the centre of the smaller pulley will be 4 feet and 8 inches. So that the distance from the centre of the large pulley to the point where the belt will cross is 9 feet 4 inches, while the other from the same point will be 4 feet 8 inches.

If a horizontal line be drawn through the centre of each pulley, extending from one to the other, and a perpendicular one also drawn through the same points, intersecting it at right angles, there will be two right-angled triangles formed—the base of one being 9 feet 4 inches, with a perpendicular equal to the radius of the 8-foot pulley, or 4 feet, while the other base will be equal to 4 feet 8 inches with a perpendicular equal to the radius of the 4-foot pulley, or 2 feet, the belt in each case representing the hypothenuse; and as the square root of the sum of the squares of the base and perpendicular of any right-angled triangle equals the hypothenuse, it is evident that the hypothenuse of these two figures must represent the length of belt between these two points.

The operation perhaps will be more simple and easier understood if the whole be reduced to inches. Then $112 \times 112 = 12544$ inches; and $48 \times 48 = 2304$ inches being the square of the base and perpendicular in inches, then $12544 + 2304 = 14848$, the square root of which is 121.85 inches. With the other proceed in the same manner: $56 \times 56 = 3136$ and $24 \times 24 = 576$, and $3136 + 576 = 3712$, the square root of which is 60.92 inches.

Now if each of these sums be doubled, and one half the circumference of each pulley with three times the thickness of the belt be added together, their sum will be equal to the whole length of belt required in inches, which, when reduced to feet, will be found to equal 48 feet and $1\frac{1}{2}$ inches.

Much has been said in favor of double belts, conveying the idea that they are not only stronger, but will transmit more power with the same stress. That there is more tensile strength in a double belt if made of equally good stock than in a single one, there is no doubt. But as far as frictional power under the same stress is concerned, the tests which have been made with both do not show any difference worth speaking of. In certain cases a double belt may transmit more power than a single one, but it is owing to the greater stress put upon it, either directly or by the extra weight—especially if running horizontally, or nearly so, with the slack side running towards the top of the driven pulley. The sag causes it to embrace a greater arc and cover more surface of the pulley.

There are objections to double belts which more than counterbalance their advantages. One is, that the stock generally used is apt to be thin and soft, and of an inferior quality. But the greatest objection is that even if they are made of good, solid stock, the uneven strain upon the two thicknesses which compose it has a tendency to tear them asunder. When two pieces of leather of even thickness and length are cemented and united by rivets, if strained around the surface of a pulley they cannot remain so: the outside piece must stretch or the inside one contract. In either case the tendency is to separate.

To illustrate this: Suppose a pulley 4 feet in diameter, the circumference of which would be 150.734 inches. Now if this pulley were entirely surrounded by a single piece of leather $\frac{5}{16}$ inch thick, it would require 151.734 inches in length to surround it; and the diameter of the pulley, including the leather, would be increased by twice the thickness of it, and the circumference would be increased to 152.76 inches. Now surround this again by another piece of the same thickness, and it will require 153.69 inches; so that the difference in length of the two pieces of leather would be equal to 1.96 inches. But as the belt is supposed to embrace only one half of the circumference of the pulley, the real difference would be about one half, or one inch; but if the same belt passed over another pulley,—which is always the case,—then the difference would amount to 2 inches, provided the pulleys were both the same size.

Now it is evident that if these two pieces were cut the same length and riveted together, when strained around the half-circumference of each pulley one piece must contract or the other stretch sufficient to make this difference in the length. If the belt remained at rest after being bent around the pulley, it would be different. But this is not the case. As soon as it leaves the pulley and becomes straightened out again both parts must resume their former relation to each other, and become of the same length. This constant unequal strain must have a tendency to break the cement and tear out the rivets in a short time, which is usually the case.

If it is absolutely necessary to use a double belt, it is better to use two single ones, one running outside of the other, with independent lacings, and having no connection with each other. When run in this manner, it will be noticed that the position of the outside belt with reference to the other will be changed at every revolution, and in a short time it will make a complete revolution around it. Belts run in this manner will work better, last longer, and give as much power, with no more trouble, as a double belt made in the ordinary manner.

The following table shows the horse-powers belts are capable of giving at a stress of 100 pounds to the inch, in width from 1 to 24 inches inclusive, and at speeds from 100 to 3000 feet per minute. The ratio of friction is taken at 40 per cent of the stress. This table is calculated from tests made by the author, and intended expressly for this work:

TABLE II.

Feet per min.	Width in inches.											
	1 in.	2 in.	3 in.	4 in.	5 in.	6 in.	7 in.	8 in.	9 in.	10 in.	11 in.	12 in.
	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.
100	.121	.242	.263	.484	.606	.727	.848	.969	1.09	1.21	1.33	1.45
200	.242	.484	.727	.968	1.21	1.45	1.69	1.93	2.18	2.42	2.66	2.90
300	.363	.926	1.08	1.45	1.81	2.18	2.54	2.90	3.27	3.63	3.99	4.35
400	.484	.768	1.45	1.93	2.42	2.90	3.39	3.87	4.36	4.84	5.32	5.80
500	.605	1.21	1.81	2.42	3.03	3.63	4.24	4.84	5.45	6.05	6.65	7.25
600	.726	1.40	2.17	2.90	3.63	4.36	5.08	5.81	6.54	7.26	7.98	8.70
700	.847	1.69	2.54	3.38	4.24	5.08	5.93	6.78	7.63	8.47	9.31	10.15
800	.968	1.93	2.90	3.87	4.84	5.81	6.78	7.75	8.72	9.68	10.64	11.60
900	1.08	2.17	3.26	4.35	5.45	6.54	7.63	8.72	9.81	10.89	11.97	13.05
1000	1.21	2.42	3.63	4.84	6.06	7.27	8.48	9.69	10.90	12.10	13.30	14.50
1100	1.33	2.66	3.99	5.32	6.66	7.99	9.32	10.65	11.99	13.31	14.63	15.95
1200	1.45	2.90	4.35	5.80	7.27	8.72	10.17	11.62	13.08	14.52	15.96	17.40
1300	1.57	3.14	4.71	6.28	7.87	9.44	11.01	12.59	14.17	15.73	17.29	18.85
1400	1.69	3.38	5.08	6.76	8.48	10.16	11.86	13.56	15.26	16.94	18.62	20.30
1500	1.81	3.69	5.44	7.25	9.08	10.89	12.71	14.53	16.35	18.15	19.95	21.75
1600	1.93	3.86	5.80	7.62	9.68	11.62	13.56	15.50	17.44	19.36	21.28	23.20
1700	2.04	4.10	6.16	8.22	10.39	12.35	14.41	16.47	18.53	20.57	22.61	24.65
1800	2.16	4.34	6.52	8.70	10.90	13.08	15.26	17.44	19.62	21.78	23.94	26.10
1900	2.29	4.59	6.89	9.19	11.51	13.81	16.11	18.41	20.71	22.99	25.27	27.55
2000	2.42	4.84	7.26	9.68	12.12	14.54	16.96	19.38	21.80	24.20	26.60	29.00
2100	2.54	5.08	7.62	10.16	12.72	15.26	17.80	20.34	22.89	25.41	27.93	30.45
2200	2.66	5.32	7.98	10.64	13.32	15.98	18.64	21.30	23.98	26.62	29.26	31.90
2300	2.78	5.56	8.35	11.12	13.89	16.71	19.48	22.24	24.77	27.83	30.59	33.35
2400	2.90	5.80	8.70	11.60	14.54	17.44	20.34	23.24	26.16	29.04	31.92	34.80
2500	3.02	6.04	9.06	12.08	15.14	18.16	21.18	24.21	27.15	30.25	33.25	36.25
2600	3.14	6.28	9.42	12.56	15.74	18.88	22.02	25.18	28.34	31.46	34.58	37.70
2700	3.26	6.52	9.79	13.04	16.35	19.60	22.87	26.15	29.33	32.67	35.91	39.15
2800	3.38	6.76	10.16	13.52	16.96	20.23	23.72	27.12	30.52	33.88	37.24	40.60
2900	3.50	7.07	10.52	14.01	17.56	21.05	24.57	28.09	31.61	35.09	38.57	42.05
3000	3.62	7.38	10.88	14.50	18.16	21.78	25.42	29.06	32.70	36.30	39.90	43.50

TABLE II.—*Concluded.*

Feet per min.	Width in inches.											
	13 in.	14 in.	15 in.	16 in.	17 in.	18 in.	19 in.	20 in.	21 in.	22 in.	23 in.	24 in.
	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.
100	1.57	1.69	1.81	1.94	2.06	2.18	2.30	2.42	2.53	2.66	2.78	2.90
200	3.14	3.38	3.62	3.87	4.12	4.36	4.60	4.84	5.06	5.32	5.56	5.80
300	4.71	5.07	5.43	5.82	6.08	6.54	6.90	7.26	7.59	7.98	8.34	8.70
400	6.28	6.76	7.24	7.76	8.24	8.72	9.20	9.68	10.12	10.64	11.12	11.60
500	7.85	8.45	9.05	9.70	10.30	10.90	11.50	12.10	12.65	13.30	13.90	14.50
600	9.42	10.14	10.86	11.64	12.36	13.08	13.80	14.52	15.18	15.96	16.68	17.40
700	10.99	11.83	12.67	13.58	14.42	15.26	16.10	16.94	17.71	18.62	19.46	20.30
800	12.56	13.52	14.48	15.52	16.48	17.44	18.40	19.36	20.24	21.28	22.24	23.20
900	14.13	15.21	16.29	17.46	18.54	19.62	20.70	21.78	22.77	23.94	25.02	26.10
1000	15.70	16.90	18.10	19.40	20.60	21.80	23.00	24.20	25.30	26.60	27.84	29.00
1100	17.27	18.59	19.91	21.34	22.66	23.98	25.30	26.62	27.83	29.26	30.58	31.90
1200	18.84	20.28	21.72	23.28	24.72	26.16	27.60	29.04	30.36	31.92	33.36	34.80
1300	20.41	21.97	23.53	25.22	26.78	28.34	29.90	31.46	32.89	34.58	36.14	37.70
1400	21.98	23.66	25.34	27.16	28.84	30.52	32.20	38.88	35.42	37.24	38.92	40.60
1500	23.55	25.35	27.15	29.10	30.90	32.70	34.50	36.30	37.95	39.90	42.70	43.50
1600	25.12	27.04	28.96	31.04	32.96	34.88	36.80	38.72	40.48	42.50	44.48	46.40
1700	26.69	28.73	30.77	32.98	35.02	37.06	39.10	41.14	43.01	45.52	47.26	49.30
1800	28.26	30.42	32.58	34.92	37.08	39.24	41.40	43.56	45.54	47.88	50.04	52.20
1900	29.83	32.11	34.39	36.86	39.14	41.42	43.70	45.98	48.07	50.56	52.86	55.10
2000	31.40	33.80	36.20	38.80	41.20	43.60	46.00	48.40	50.60	53.20	55.68	58.00
2100	32.97	35.49	38.01	40.74	43.26	45.78	48.30	50.82	53.13	55.86	58.42	60.90
2200	34.54	37.18	39.82	42.68	45.32	47.96	50.60	53.24	55.66	58.52	61.16	63.80
2300	36.11	38.87	41.63	43.62	47.38	50.14	52.90	55.66	58.19	61.18	63.94	66.70
2400	37.68	40.56	43.44	46.56	49.44	52.32	55.20	58.08	60.72	68.84	66.72	69.60
2500	39.25	42.25	45.25	48.50	51.50	54.50	57.50	60.50	63.25	66.50	69.50	72.50
2600	40.82	43.94	47.06	50.44	53.56	56.68	59.80	62.92	65.78	69.16	72.28	75.40
2700	42.39	45.63	48.87	52.38	55.62	58.86	62.10	65.34	68.81	71.82	75.06	78.30
2800	43.96	47.32	50.68	54.32	57.68	61.04	64.40	67.76	70.84	74.48	77.84	81.20
2900	45.53	48.01	52.49	56.62	59.74	63.32	66.70	70.18	73.37	77.14	81.62	84.10
3000	47.10	50.70	54.30	58.20	61.80	65.40	69.00	72.60	75.90	79.80	85.40	87.00

CHAPTER XXIV.

ADVICE TO YOUNG MEN — THEY SHOULD MAKE THEMSELVES PROFICIENTS IN THEIR BUSINESS —FREQUENT CHANGES NOT ADVISABLE—PROPER STUDIES FOR THE YOUNG MECHANIC IN ORDER TO FIT HIM FOR FUTURE USEFULNESS, ETC.

In conclusion, a few words of advice to young men may not be amiss.

The question is often asked why it is that planing-mill operators as a class are not as competent men as may be found in other mechanical businesses. There is scarcely an accident or a breakdown but may be traced directly or indirectly to carelessness or neglect on the part of the operator. To a close observer this question can be satisfactorily answered. In the first place, comparatively few young men adopt this as a regular business or permanent occupation, and do not serve the necessary apprenticeship to qualify them for the duties and responsibilities devolving upon them. In the second place, men who have served an apprenticeship and thoroughly fitted themselves for the duties and responsibilities of the position cannot afford to give their time and energies to a business that in the past has offered so little inducements in the small salaries that most planing-mill proprietors are willing to offer; consequently many abandon this business for something that may offer them better inducements. In fact, it would seem as if a large majority of planing-mill operators adopt this business as a sort of makeshift until they can find something better.

Such men are not expected to devote their mind and energies to a business that they expect to remain in only a few months. A young man, for instance, gets tired of farming, and makes up his mind to try something else. He goes to the nearest town and applies for a job in a planing-mill; works around a few months; watches the men who are running the machines: it all looks simple enough to him, and after awhile he makes up his mind that he can do that work just as well as anybody. He goes to the next town, and obtains a situation in some mill as a competent operator; works until he has a breakdown, or the machine gets in such a condition that the customers complain of bad work and threaten to leave; when, if not discharged he will pick up his traps and try something else. So he floats around between planing-mills, saw-mills, and logging-camps; and if he should happen to continue around planing-mills long enough he may pick up sufficient knowledge in time to become a second or third class operator: but the chances are that one or two seasons will wind up his career, and he will either return to the farm, which he should never have left, or try some other business, with like results.

There is a class of planing-mill operators, however, who have learned this business in the regular way, and have become experts in their chosen profession, many of whom I have the pleasure of being personally acquainted with. Such men are ornaments to their profession, and profitable to their employers at any salary; and there *are* planing-mill proprietors who appreciate such men, but I am sorry to say that they are not as numerous as they should be.

To this class of operators I have no reference—their own work and the efficiency of their machines are a sufficient recommendation; but I do contend that a man, to have the care and management of wood-working machinery, should be a proficient at the business. A young man starting out in life, who intends to make this his business and profession, should go into some first-class mill, and, under a competent foreman, serve a regular apprenticeship, and devote all the energies of his mind to the business unreservedly, until he has mastered all the principles and details of the different machines that may come under his charge in after years.

It is by this means only that he can make a success of it and command the highest price for his labor and skill, and superintend with intelligence and authority the workmen under his charge. He should not only aspire to become a good operator, but should endeavor to become a master-mechanic in his chosen profession. He should devote his leisure time to the study of such mechanical works as relate to his business, instead of throwing it away, as many young men do, in reading the trashy literature of the day in the shape of dime novels, which impart no useful information, or in attending variety shows—both of which are a total loss of time. He should remember that "time once past never returns: a moment lost is lost forever." He should also study mathematics, philosophy, and the natural sciences; thereby not only fitting himself to discharge his duties in a more intelligent manner, but also for any other useful occupation in after life in case of accident or disability.

By making himself master of those principles of science—more particularly those which are most intimately connected with his business, he may be laying unawares the foundation for future discoveries in mechanical improvements that may be a source of great benefit to the public and profit to himself.

Benjamin Franklin, when learning the trade of a printer and devoting all his leisure time to the study of philosophy and the natural sciences, probably never dreamed of the brilliant discoveries that he would make in after-life, or the fame that would attach itself to his name and descend as a living monument to generations yet unborn.

Elihu Burritt, the learned blacksmith, who commenced learning his trade when quite young and with a very limited common-school education, at the age of forty was master of fifty-two languages, and wrought at his anvil during all that time, only devoting his leisure time to study until the demands of the public called him to a more public, beneficial, and profitable occupation.

I could name a large number of men among my personal acquaintances who commenced their apprenticeship poor, and with but little education, but who by devoting their leisure time to study, have ascended to the top of the ladder, and are now filling places of responsibility and trust, and have secured, many of them, a large competency; while others, from the same shops, who devoted their leisure time to novel-reading and attending places of amusement that were no benefit to them, are now, in their declining years, still working as common hands, and for wages that no more than enables them to eke out a bare existence. Such examples are to be found in every shop and in every line of mechanical business, and should be a living example to young men *not* to go and do likewise.

When a young man decides to learn a trade or profession, whether it be the care and management of wood-working machinery, the charge of a lumber-yard, or any of the mechanical trades, he should cultivate a spirit of contentment, and realize that when he is working for the interest of his employer he is working for his own. I do not mean that he should content himself to always remain in just the same position he may fill at the time, but by study and perseverance fit himself for advancement to the higher and more responsible positions that the same line of business may afford. It is a well-known fact, that may be demonstrated by numerous living examples, that some of the largest and wealthiest lumber-dealers in the country began life as common laborers in the yard, and by energy, strict integrity, and careful attention to business in time succeeded in rendering themselves almost indispensable to their employers, and finally became partners, and lastly proprietors themselves.

The young man who is satisfied with his business and adheres to it, and endeavors to make himself useful in whatever position he may occupy, presents a much more respectable figure in the eyes of the public than one who is constantly changing from one thing to another and undertaking hazardous enterprises, which often end in debt and ruin. A man who has been engaged in a mercantile business all his life will not be apt to succeed well as a manufacturer; neither would a blacksmith be apt to succeed as a merchant.

There is an old saying that is applicable to every one who has been brought up to a regular trade or profession, and that has more truth than poetry—"Keep to your shop, and your shop will keep you."

I admire the old English style. If a man is a successful manufacturer or mechanic, no matter how wealthy he may become, his sons and grandsons are not too proud to be known as manufacturers and mechanics themselves, and write themselves with pride as the successors of the old firm.

For honesty, integrity, and genuine respectability, commend me to the intelligent, hard-working mechanic.