SHAFTING, PULLEYS, ETC.

IN designing a mill or manufacturing plant, says C. R. Tompkins, M. E., one of the most important features, aside from the arrangement for good and sufficient power, is the line of shafting and the necessary pulleys for the purpose of transmitting the power to the several machines to be used. Now, it is just as important that good judgment be manifested in this part of the plant as in any other. The fact is that much needless expense is often caused in the first instance, besides a continual loss of power in the second, by an injudicious selection of the shafting.

A line of shafting unnecessarily heavy, with pulleys and couplings to match, not only involves a greater expense in the first place, whether it is purchased by the pound or foot, but the extra amount of friction on the journals caused by that weight is a factor that should also be taken into consideration. It is a well-known fact that the frictional resistance with all bodies in sliding contact is in direct proportion to the weight pressing them together, so that the weight of a line of shafting with heavy pulleys, no matter what the speed may be, will exert a constant frictional resistance in proportion to the weight.

While there can be no question as to the economy in all cases of using a lighter shaft at greater speed than was formerly the case, still it is not advisable under any condition to go to extremes in either case, for the reason that, with a little forethought and calculation in the first instance, we may avoid either.

As a rule, in all modern mills and factories, the tendency has been toward lighter shafting and pulleys of small diameter, with a corresponding higher speed, and there is no question but much more satisfactory results have been obtained. The shortest and most reliable rule that has been found to obtain the torsional strength of all sizes of shafting, is to multiply the cube of the diameter by 600, and this product by the number of revolutions per minute, and divide by 33,000 for the horse power. The ultimate torsional strength of a shaft is not the power required to twist it off, but a power not quite sufficient to give it a permanent set.

Now, according to this rule, which has been verified in many cases, a shaft 3 inches in diameter at 200 revolutions per minute should not be required to safely transmit the 32 horse-power, while by the same rule a shaft of 2 inches diameter of the same quality of iron running at 300 revolutions will safely transmit 43 horse-power. Now, all other things being equal, it is evident that where not over 35 horse-power is required, a 2-inch shaft at 300 revolutions per minute is the most economical. For example, the weight of a line of 3-inch shafting 40 ft. long, without couplings and pulleys, is 955 pounds, while a 2 inch shaft of the same length weighs 424 pounds, a difference in weight of 531 pounds. Now, the frictional resistance, as before stated, is in proportion to the weight, and without any lubrication is estimated that it amounts to 25 per cent., but with a good lubrication this may be reduced, according to the best authorities, to 8 per cent.

Now, taking 8 per cent. as the average, we find that with a 3-inch shaft we have a constant frictional resistance of 76.40 pounds to contend with, while on the contrary, the frictional resistance upon a 2-inch shaft amounts to but 34 pounds. Here an important question arises which has been frequently discussed, and that is whether the speed has anything to do with the frictional resistance.

One authority says that "with hard substances and within the limits of abrasion, friction is as the pressure, without regard to surface, time or velocity." In another place the same author states as follows: "A regular velocity has no considerable influence on friction; if the velocity is increased the friction is greater, but this depends on the secondary or incidental causes as the generation of heat and the resistance of the air."

Now, without entering into a full discussion of this question, if we take the question of speed into consideration, the argument is still in favor of the lighter shaft. We found the frictional resistance in the 3-inch shaft without taking the speed into consideration to be 76.40 pounds. Now, if we multiply this by the speed, as some contend it should be, we have a total resistance of 15,280 pounds per minute to overcome, while with the 2-inch shaft by the same proposition we have 10,200 pounds per minute to overcome, showing a difference in frictional resistance in favor of the 2-inch shaft of 5,080 pounds per minute.

Now, as to the question of pulleys. In order to obtain say 900 revolutions from a pulley driven from a 3-inch shaft at 200 revolutions per minute, it will require a pulley 36 inches in diameter, while the same power and speed may be obtained from the 2-inch shaft at 300 revolutions from a pulley 24 inches in diameter.

Now, in the foregoing argument in favor of lighter shafting and higher speed, the torsional strength of the shaft has only been taken into consideration, and while the torsional strength of a shaft of a certain diameter may be amply sufficient to transmit the required power with perfect safety, still the lateral strength must also be considered. A shaft, no matter what the size may be, in order to fulfill all the conditions of practical use, must possess sufficient lateral strength to stand the pull of the belts, together with the sudden shocks which may be sustained when heavy machines are started suddenly, and for this reason, under peculiar conditions, it may be advisable to use a shaft a trifle larger than the rule calls for. But under ordinary conditions, if the distance between the boxes or hangers is in proportion to the size of the shaft, it will not be found necessary to vary much from the foregoing rule.

One of the most common faults in erecting a line of shafting is in too great a distance between the bearings, and it is often the case that a shaft abundantly heavy is rendered ineffective from this cause, and when a machine is started the shaft springs, so as to cause the belt to slip, unless the pulley happens to be close to the bearing.

While it is good practice in all cases where the conditions will admit to run all heavy pulleys as close to the bearing as possible, still it is not always practical to do so, consequently the size of the shaft and the distance between the bearings should be so calculated that there will be sufficient lateral strength to admit of placing the pulleys upon any part of the shaft between the bearings.

There is no question but as a general rule a shaft that possesses sufficient torsional strength to perform the work, with a modern allowance for contingencies, will, if the bearings are placed at a proper distance apart, also possess sufficient lateral strength for all practical purposes.

In practical experience it has been found that the most reliable rule for this purpose is to take three times the diameter of the shaft in inches for the distance from center to center of the bearings in feet. Thus a shaft of 2 inches in diameter should be 6 feet from center to center of its bearings. One of 2½ inches would call for 7 feet and 6 inches, while one of 3 inches may be 7 feet, and so on.

WHY SAP FLOWS IN TREES.

DISCUSSING the flow of sap in trees, one writer presents the following interesting theory. The maple tree is active in the summer and passive in winter. Pressure, suction and zero are conditions of the tree when not in leaf, when at rest and passive. Varied weather as to temperature is the case of these varied conditions. Under certain conditions the whole tree may be in pressure, while another part of the same tree may have been in suction. When the tree is in pressure, it is throwing out moisture sap, whether tapped or untapped. When the tree is in suction, it is reversed, taking in moisture of water, whether the tree is tapped or not. When the tree is tapped the pressure is visible. To make the suction visible, connect a glass tube to the spout, a round wooden one, by rubber, fill the tube with water or sap, or even syrup, when the tree is in suction, and you will see the contents passing down the tube and of course passing into the tree. Pressure and suction exists all the same if the tree is not bored, but, being unseen, it is recognized little even by vegetable physiologists. Pressure may be measured with the steam gauge, and also with a mercurial gauge, while suction can be measured with a mercurial gauge only.

The highest pressure that I have noticed was 34 pounds on a square inch. This would hold a column of water over 60 feet high. The pressure of the atmosphere at the sea level is 15 pounds upon a square inch. This amount of pressure is exerted on every square inch of the outside surface of the tree and is balanced by the same amount of internal pressure, so that the 34 pounds of internal pressure was in excess of the outside pressure; hence, even if the tree is not tapped, there must be moisture passing to the surface through the pores and connecting with the atmosphere until equilibrium is restored, and suction or zero is reached. If certain conditions produce pressure, then reversed conditions must produce suction, the opposite condition. When the tree is neither in pressure nor suction, then its condition is zero. In good sap weather, as a general law, the tree is in pressure during the day and in suction through the night. In poor sap weather zero conditions prevail.

Pressure. What is it? This can only be understood by an understanding of the internal make-up of the tree. It is supposed that there are 100,000,000 cells in every cubic inch of maple wood. These cells are supposed to be like small boxes, with covers, piled one upon another, so that there are two partitions between every box or cell. These cells are filled with gases, air and water, together with some other materials or elements. Now we are prepared to understand the philosophy of the pressure. As the sun warms up the outside of the tree, the air and gases expand in all the cells so warmed up, occupying a larger space, so that the pressure must be proportionate. It is not so much the expansion of the cells as it is their expansible contents. The moisture or watery parts are forced out through the pores of the tree, and if a small maple tree is carefully scraped to the wood, instantly the whole surface will be covered with tiny drops of moisture, showing what is taking place all over the surface. If a tree is bored, the pressure is liberated so much, and if a gage is attached to the tree, it will show it and even measure the amount. Now a vacuum results. As a cool night is coming on, these expansive elements are contracting, doubly increasing the vacuum. Now pressure changes to suction, and the glass tube shows it. The equilibrium of the tree is restored.

CUT OF CANADIAN LOGS.

AN interesting contribution to the discussion of the saw-log trade and lumber duties, is the following from the Lumber World, of Buffalo:

"According to reports from Saginaw and other points in Michigan, the present season will witness the sawing of large amounts of Canadian logs in Michigan mills. The total that will cross Lake Huron from Canada to Michigan this season is set down at 350,000,000 feet of logs. So large an importation of logs, much of them by firms who own mills in Canada would seem to mean that the Americans operating in Canada do not intend to let their American mills fall into decay. It may also mean that they do not find the operation of saw-mills in Canada either so easy, so attractive, or so profitable as they expected to find it. Again, it may mean that they find the transportation of logs by lake so cheap that they find at least as much profit in sawing on this side as they find in the sale of lumber sawed in Canada and brought over by lake and rail. Viewed in any light, the movement is so large as to form an interesting feature of the trade. It is suspected that the Americans operating in Canada do not expect to see the present free lumber tariff standing two years from the present time, and that their expectation of a restoration of the tariff in 1897 or 1898 will prevent them from going to great expense to erect large mills in Canada. With Canadian saw-millers rushing their mills to their full capacity, with many Americans operating saw-mills on both sides of the border, and with American mills cutting about an average of lumber, in addition to the very large amount of scorched lumber that has been and is being 'cut to save it,' there is no immediate prospect of an advance in the prices of any of those lines of lumber concerned in these transactions in the markets of the United States."

SAWS should run at high speed to accomplish the best results. Short, slim teeth can be run on lighter cuts. High-speed saws will stand heavier feed in proportion to the length of teeth than the slower speeds. Long teeth will not hold corners well. A saw properly adjusted at a high speed will not run out in slabbing, nor into the cut after passing the center of the log.