

men against selecting the engineering profession on account of the over-supply of men in this branch.

These abnormal conditions have also created a system of industrial despotism unknown in America. It is not unusual that the young graduate in order to obtain a position is required to sign a contract in which he agrees that he will not enter into the employ of a competing firm during a period of from two

to four years, or, in extreme cases, up to ten years, after the time of leaving the employer with whom this contract is made. The older employees are largely tied to their positions by the pension system of the employers. Another abnormal condition which may be mentioned is that an employee has no right to patent anything that has been conceived in connection with his employment, and the inventions

which he makes are the property of his employer. His name, in fact, does not even appear in the patent application. In many cases access to the works is entirely denied any employee not directly working in the shops, and sometimes one will hear persons expressing their wish to see the works where for a period of five years they may have been working in the drafting-room or the laboratory.

## ROPE-DRIVING.

### THEIR ECONOMY AND EFFICIENCY.

BY J. STORMONTH.

THERE are certain features of rope-driving that need attention if difficult drives are to be successful from the point of view of giving little trouble, and costing little for upkeep. We assume that the grooves in all pulleys connected are cut equal in depth and to the same gage. The most satisfactory drives, as a rule, are those in which the pulleys are equal, or nearly so, in diameter. Should one rope be smaller in diameter than the others, with equal pulleys, the relative speeds are still alike. One rope may drive at 4 feet diameter and another at 47½ inches, and yet both pull together. It is when such drives as 25 feet to 5 feet are employed that troubles arise. Some have even a greater ratio.

In Fig. 1 a rope and groove are shown diagrammatically. To find the difference in depth of a 1¾-inch rope we give the following solution. The angle  $CAD$  is 90 deg.,  $ABC = 22½$  deg.,  $DAE = 67½$  deg., and  $CAE = 22½$  deg. The cos.  $CAE = 0.9238 \times \frac{7}{8}$  for 1¾-inch ropes = 0.8083. The sine  $DAE = 0.8083$  and

the cosine =  $\frac{3826}{9238} \times 9238 = 1.95 = DAE$ .

In the same manner  $DE$  for a 1½-inch rope is 1.81, a difference of 0.14 inch = 9/64. The 1½-inch rope sinks 9/64 inch deeper into the groove than the 1¾-inch rope, and the effective diameter of the pulley with the former rope is 9/32 inch less.

Let us conceive of two ropes on the 25-foot to 5-foot drive. One new 1¾-inch rope drives at the 5 to 1 ratio. The other rope is worn to 1½ inch diameter, and its effective driving diameter on the pulley is 9/32 less than the 25-foot. To keep the ratio correct, the driving diameter of the small pulley should be less than 5 feet by 1/5 of 9/32 = 9/160. But the rope sinks into the

groove 9/32, so that  $\frac{45}{160} - \frac{9}{32} = \frac{9}{160} - \frac{45}{160} = \frac{36}{160} = \frac{9}{40}$  is the amount by which the diameter is less than the normal ratio of 1 in 5. The speed gained by the smaller rope is 7 1/5

$\frac{32}{32} \times 3.14$  in one revolution. At a speed of 300

revolutions per minute the gain in speed when the small rope or ropes is driving is 67½ revolutions of the smaller pulley in one hour. This means that the smaller ropes, if possible, turn the 5-foot diameter pulley inside the larger ropes 810 times in 12 hours, and each of the larger ropes is therefore to some extent a brake.

Subjoined is a table showing by how much, in a drive of 1¾-inch diameter ropes, the smaller pulley is lessened in the ratio of driving diameter when 1½-inch ropes are used:

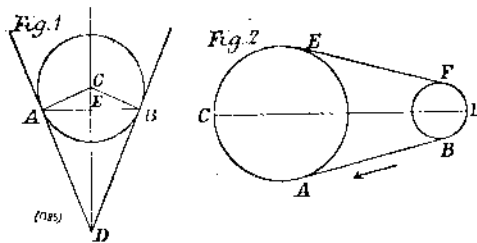
Reduction in 32nds	14/5,	2¼,	3,	4½,	6,	6¾,	7 1/5
Ratio of drivers	5,	4,	3,	2,	3,	4,	5
to driven	4,	3,	2,	1,	1,	1,	1

The effect of any of the smaller ropes driving is that the larger ropes sag on the underside. In practice a set of twelve ropes is placed, say, and after running a few days one of the ropes begins to hang on the underside, which we assume to be the driving one. This may be caused by irregular tension when the ropes are laid, by slightly irregular diameter of rope, or by unequal stretching before splicing. The rope runs round without pulling. The other eleven ropes do the driving and tightening themselves in the grooves, the slack rope is pulled taut on the top side sufficiently to still further stretch it. If the race be shallow, the rope is taken off, or, happily, it is re-spliced. If this is done so as to stretch the rope to the same diameter as the others, all may be well. But when a competent splicer is not at hand, it may lie off until the others need re-splicing. By that time the driving-ropes will be further reduced in diameter, and the relative difference between the ropes be further increased. Should the ropes drive a generator, the rope may merely lie off till the ropes are stretched and the generator is drawn back. But if the ropes stretch, they are slightly reduced in diameter, so that the odd rope will still be larger in diameter and will again hang on the underside.

When the ropes are driving light, and a number of them are driving on a smaller diameter than the others, the small pulley is drawn round within the larger diameter ropes. This sliding is then apt to proceed by fits and starts instead of at a constant ratio. One of the ropes is drawn taut on the upper side, then the pulley slides within it a few inches. The result is the rope, with the sudden release and slackening, surges upward. In these cases the rope or ropes may jump out of their grooves or even do damage.

It is obvious that in any ordinary drive from a larger to a smaller pulley, a new rope being placed with a worn set will simply act as a brake, the worn ropes driving the faster. Extra work is thus placed on the worn ropes and their lives are proportionally shortened. It is much better that the worn ropes should be allowed to wear out and a new set then be provided.

Let us suppose that eight new ropes are placed on a twelve-rope drive, and four of the old ones are allowed to remain. These four drive faster than the new ropes, but cannot overcome the new ropes. They therefore slide in the grooves, the eight new ropes determining the speed. As the old ropes slide, their spiral lay tends to make them revolve, and they rapidly wear out.



Drives may be seen in which the ropes revolve sufficiently to keep them round, and yet run for years. In ordinary circumstances the ropes become V-shaped, but when the ropes slide over the grooves they both revolve and wear rapidly. Rubbing the ropes with one or other of the graphite compounds enables the ropes to slide, and steadies a drive where the ropes are pulling unequally. The effective grip on the pulley is necessarily lessened. If much sliding takes place, the ropes will wear the grooves, damaging the drive irreparably unless the pulley is again turned. It is on the small pulley the sliding takes place, as the arc of contact is greater on the large pulley.

The difference of ¼ inch in diameter may be said to be excessive in the case of a recently-spliced set. But 1¾-inch ropes are sometimes reduced to 1½ inch in diameter in less than twelve months. On the other hand, when the ratio is not great the ropes have a tendency to automatically adjust themselves, and this may often be aided by wise handling of the ropes. Where the dividing line takes place, where on the one side the ropes get worse, and on the other side get better, it is difficult to say, and obviously varies with the special circumstances. Let us say the drive is 2 to 1, and that four ropes are 1¾ inches and six are 1 11/16 inches in diameter. The latter sink about 1/32nd in the groove and drive. The rubbing of the pulley within the larger ropes reduces these slightly—it may be by veing them—and they begin to pull together. If the majority of the ropes are larger, then the smaller ropes slightly slide, and, in sliding, tend to revolve, owing to the lay-up of the ropes. This sliding in the spiral lay makes the rope practically longer, and adjustment is again secured. If this adjustment does not take place, then, as already shown in the case of old and new ropes, the smaller ropes are rubbed to destruction.

When ropes are much veed they deteriorate rapidly, as a rope cannot drive with a ¼ vee. The larger part of the vee cannot drive at the same speed as the smaller, and a constant ruffling of the surface of the vees takes place accordingly. If the center line of the rope is the neutral axis, we may expect the bottom of the vee on any rope to be compressed, as it is at the bottom of the groove. This is what takes place, the bottoms of the vees on the rope or ropes showing a crushed appearance on the surface. It is notable that

ropes markedly veed are soft and limp on the part of the rope which is outside, as if the ropes worked on the neutral axis as on a horizontal hinge. Ropes which revolve become smooth, and even hard, on the outside.

Assume that the smaller pulley drives the larger at the same ratio as before—5 feet to 25 feet—and that the drive is one of six ropes, four of which are 1¾ inches and two are 1½ inches, as before. The smaller ones do the driving at a slower speed necessarily than would be the case if the larger ropes drove. The pulley is therefore turned within the large ropes, which are thus reduced by wear. Or, what is more common, the two larger ropes are caused to revolve so that ¼ inch more rope is given off at each revolution; but being given off on the spiral, the net length is ¼ inch less. The actual speeds are thus equal, and the proportions hold for the larger pulley also.

When single ropes are led to driven pulleys on different floors or on different drives, the troubles referred to are avoided. And when the various drives are of two, three, or four ropes, the difficulties are proportionately minimized.

The action of centrifugal force at high speeds is both disadvantageous and complicated. The action on a rope-drive is not the same as on a rope, let us assume, revolving in space, for in this latter the stresses are practically uniform, excluding gravity. At D, Fig. 2, the tendency of the rope to descend vertically is overcome by the pull of the rope A B, a pull which is uniform along its length, and which is the driving tension plus the pull needed to overcome the centrifugal force from D to B. The centrifugal force from A to C lessens the grip of the rope at that part, and if we roughly assume it to be equal to the centrifugal force at D B, then the grip of the rope at A C is the grip due to the driving tension only. The large pulley, owing to this and to its larger arc of contact, is not the one on which the ropes will slide. If we now examine E F, the slack side, it is apparent the centrifugal force at E is so far counteracted by the weight and tension of E F. But at F the tendency is for the rope to overshoot the pulley, thus lessening the arc of contact F B. In belt-driving on a small pulley, from another pulley at an angle above it, this effect is quite evident, the beholder being able to see between the belt and the pulley at the running-on side of the small pulley. Should F D B be a generator with the ropes at 5,000 feet per minute, the ropes at E F may dance at the high speed and on a light load. The tendency is to tighten up the generator and probably stress the ropes severely.

The reader may see that if the small pulley is at a convenient driving angle above the large one, the force of gravity counteracts so far the centrifugal force as regards the small pulley. And as 1½-inch diameter ropes are approximately three-fourths of the weight of 1¾-inch ropes, they are better for fast drives, their lessened weight giving less centrifugal force.

Should there be irregular turning moment in the engine, due, say, to excessive compression, the effect may be visible in the tremor of the ropes. Slack ropes on a light drive at starting will sometimes behave very erratically till the load is applied, when they will run smoothly. The solution, the writer thinks, lies in the fact that the driving tension being light, the ropes are not tightened in the grooves of the driving pulley, and any slight variations in diameter of the ropes causing tension and release on various ropes, as already pointed out, causes swinging and flying in an alarming fashion. When the ropes are tightened by the load, the revolving action, with its adjusting effect, takes place, and smooth running results.—Engineering.

Zinc is often used to prevent the corrosion of boilers. Its efficiency is due to the fact that any metal with a greater tendency than iron to dissolve on which hydrogen is liberated with more difficulty than on iron, will protect the latter at the expense of the more soluble metal. The protection, however, becomes ineffective in pure water at a distance greater than an inch. Salt or some other electrolyte will extend the zone to 20 inches or more.