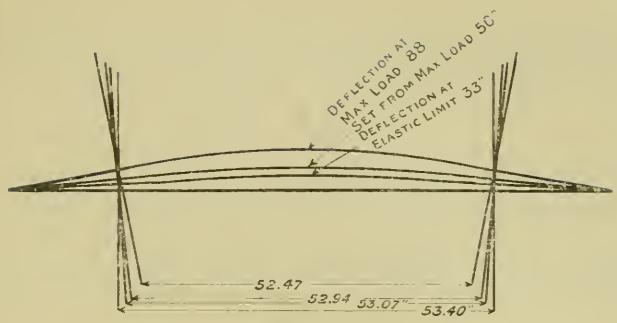

Fig. 4. Tests of a Wrought Iron Car Axle.

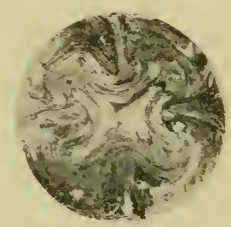

Fig. 5.

Fig. 5. Car Axle.

Subdivision of Power. By J. J. Flather.

While economy in the use of power should be secondary to increased output, yet careful attention to details will often greatly reduce the useless waste of power.

It is well known among engineers that there is a very great percentage of loss due to shaft friction, which, in shops where the buildings are more or less scattered, is probably not far from 75 per cent. of the total power used. In two cases known to the writer these losses are 80 and 93 per cent. respectively.

No matter how well a long line of shafting may have been erected, it soon loses its alignment, and the power necessary to rotate it is increased.

In machine shops with a line of main shafting running down the center of a room, connected by short belts with innumerable countershafts on either side, often by more than one belt, and, as frequently happens, also connected to one or more auxiliary shafts which drive other countershafts, we can see why the power required to drive this shafting should be so large.

There is no doubt, however, that a large percentage of the power now spent in overcoming the friction of shafting in ordinary practice could be made available for useful work if much of the present cumbrous lines of shafting were removed.

Manufacturers are realizing the enormous loss of power which ensues from the present system of transmission, and we find a general tendency to introduce different methods by which a part of this loss will be obviated. Among these are the introduction of hollow and lighter shafting; higher speeds and lighter pulleys; roller bearings in shaft hangers; and the total or partial elimination of the shafting.

Independent motors are often employed to drive sections of shafting and isolated machines, and among these we find steam engines, electric motors, gas engines and compressed air motors, although the latter have not been used for this purpose to any extent in this country.

For the average machine shop, short lengths of light shafting may be employed to good advantage, and the various machines, arranged in groups, may be driven from one motor. By this method fewer motors are required and each may be so proportioned to the average load that it may be run most of the time at its maximum efficiency. When short lengths of shafting are employed the alignment of any section is very little affected by local settling of beams or columns, and since a relatively small amount of power is transmitted by each section, the shaft may be reduced in size, thus decreasing the friction loss. Moreover, with this arrangement, as also with the independent motor, the machinery may often be placed to better advantage, in order to suit a given process of manufacture; shafts may be placed at any angle without the usual complicated and often unsatisfactory devices; setting-up room may be provided in any suitable location as required without carrying long lines of shafting through space. This is an important consideration, for not only is the running expense reduced thereby but the clear head room thus obtained free from all shafting, belts, ropes, pulleys and other transmitting devices, can be more easily utilized for hoists and cranes, which have so largely come to be recognized as essential to economical manufacture.

There is also less liability of interruption to manufacture on account of the subdivision of power, and, in case of overtime, it is not necessary to operate the whole works with its usual heavy load of transmitting machinery.

Another advantage is the adaptability of the system to changes and extension; new motors may always be added without affecting any already in operation, and the ease with which this system lends itself to varying the speed of different unit groups is a very potent factor in its favor.

In the choice of motors for this work the steam engine has heretofore been used, especially where the units are relatively large. An interesting example of this is noted in the sugar refinery of Claus Spreckles, in Philadelphia, in which there are some seventy-five Westinghouse engines about the works, many of them being of 75 and 100 horse-power.

A similar subdivided plant involving forty-two engines was erected several years ago at the print works of the Dunnell Company, Pawtucket, R. I. More recently, however, the electric motor has superseded the steam engine for this work, as its economy and convenience over the latter is now thoroughly recognized.

For isolated machines and for heavy machines that may be in occasional use the electric motor is particularly well adapted as a source of power, for such a means of transmission consumes power only when the machine is in operation.

This is true also of compressed air, and we find numerous instances where it has entirely replaced steam even in large work. Thus, at the steel works at Terni, Italy, a 100-ton hammer is worked by compressed air, and also two large cranes, one having a capacity of 100-tons and the other 150 tons. Compressed air in some cases is also superseding steam for operating pumping machinery.

In Paris, according to Prof. Unwin, compressed air motors are even used to drive dynamos for electric lighting. At some of the newspaper offices there are motors of 50 and 100 horse-power driving presses, and in shops and factories these motors are used to run lathes, saws and various other machines.

In the transmission of air, within reasonable limits, the loss in transmission need not be considered, for although there is a slight loss in pressure due to the frictional resistances of the pipes, yet there is a corresponding increase in volume due to fall in temperature, so that the loss is practically inappreciable.

In the compression of air, with steam actuated compressors, there are various sources of loss, which, in the aggregate, will vary from 25 to 45 per cent. of the total power of the machine.

The greatest loss of efficiency is that in the air motor. It is usually impracticable to reheat the air with any degree of economy when employed intermittently, and we find very generally that the air is used at normal temperature for the various purposes to which it is applied. In small motors (1 to 2 horse-power) the loss may be as much as 65 per cent. when the air is used without expansion. With larger motors (75 horse-power), using a reheater and hot air jackets, the motor loss has been kept within 20 per cent. at full load.

These results and others would indicate that compressed air as now used is not at all efficient as a source of motive power, since the combined efficiency of compressor and motor, even under favorable conditions, is not more than 50 per

cent. of the available energy put into the compressor. In other cases the efficiency is as low as 20 per cent.

There should be no comparison between the cost of the transmission of power by compressed air and its so-called rival, electricity, since each has its own field of usefulness, yet it may be interesting to note for our present purposes the efficiency of electric transmission.

A modern generator, belted from an engine, will have an efficiency of about 90 per cent. when working under favorable conditions. but as the average load is ordinarily not more than two-thirds full load, and often much less, the efficiency will not usually be more than 85 per cent. Since the engine friction was added to the losses in compression, so also it should be considered here, in which case the efficiency of generation will lie between 75 and 80 per cent. With a pressure of 220 volts, which is very suitable for ordinary shop transmissions when both light and power are to be taken off the same line, the loss in transmission need not be more than 5 per cent. so that the efficiency at the motor terminals will not be far from 75 per cent. With motors running under a nearly constant full load the efficiency of motor may be 90 per cent., but with fluctuating loads this may fall to 60 per cent. at quarter load. In numerous tests made by the writer the average load on several motors in machine shops was only about one-third of the rated capacity of the motor.

It is interesting to note that in recent tests made at the Baldwin Locomotive Works it was found that with a total motor capacity aggregating 200 horse-power, a generator of only 100 horse-power was sufficient to furnish the current, and ordinarily only 80 horse-power was required.

Under these conditions when the driven machines are not greatly over-motored we may assume a motor efficiency of 80 per cent., which may be less or greater in individual cases. The combined efficiency, then, of generator and motor working intermittently with fluctuating loads will be about $75 \times 80 = 60$ per cent. of the power delivered to the engine.

For greater distances than those which obtain in plants of this character the loss in transmission will be greater, and higher voltage must be employed in order to keep down the line loss; while it is possible to put in conductors sufficiently large to carry the current with any assumed loss, yet the cost of the line soon becomes prohibitive with low voltage. In work of this kind it is well to remember that while the efficiency may be very high the economy may be very poor, and good engineering is primarily a question of good economy, all things considered. It is not the most efficient plant which produces the greatest economy. While it is interesting to know that a certain amount of power may

be transmitted a given distance with a high efficiency, it is more important to know that the same amount of power could be obtained at the objective point for one-fourth the cost of the former.

Lafayette, Ind., Dec. 30, 1896.

Economy in the Design of Electro-Magnets. By W. E. Goldsborough.

Published in the Electrical World, Vol. XXIX, p. 196, Feb. 6, 1897.

An Efficiency Surface for the Pelton Motor. By W. K. Hatt.

Published in the Journal of the Franklin Institute, June, 1897.

On Seiches. By A. W. Duff.

Some Experiments on the Phenomena of the Elevation of the Elastic Limit. By W. K. Hatt.

Viscosity as a Function of Temperature. By A. W. Duff.

[Abstract.]

The author shows the insufficiency of the formulæ proposed by Poisenille. Slotte, Koch, Grätz and others, and finds generalized formulæ.

$$\left.\begin{aligned} \eta &= C\left(\frac{t+a}{t+b}\right)^n \\ \eta &= Ca^{-\tan^{-1} a(\beta+t)} \end{aligned}\right\}$$

which are in agreement with all data hitherto obtained, the former applying to water and most substances of slow variation of viscosity, and the latter to glycerine, mercury and most substances of rapid variation of viscosity.