[From Journal of the Franklin Institute.]

TRANSMISSION OF MOTION.

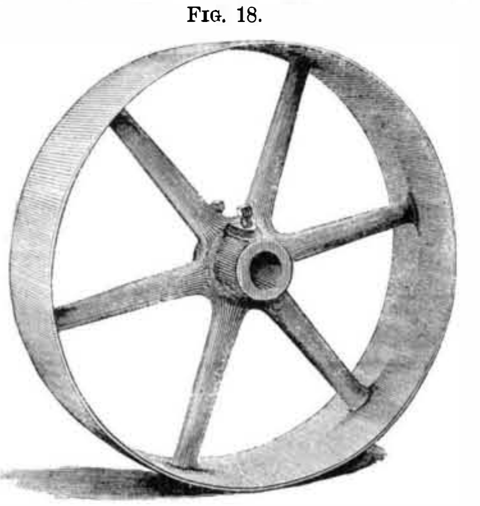
A Lecture delivered by Coleman Sellers, at the Stevens Institute of Technology, Hoboken, N. J., February 19th, 1872.

NUMBER IV.

When very long lines of shafting are constructed of small or comparatively small diameter, such lines are liable to some irregularities in speed, owing to the torsion or twisting of the shaft as power is taken from it in more or less irregular manner. Shafts driving looms may at one time be under the strain of driving all the looms belted from them, but as some looms are stopped the strain on the shaft becomes relaxed, and the torsional strain drives some part of the line ahead, and again retards it when the looms are started up. This irregularity is in some cases a matter of serious consideration, as in the instance of driving weaving machinery. The looms are provided with delicate stop motion, whereby the breaking of a thread knocks off the belt shaft and stops the loom. An irregular driving motion is apt to cause the looms to knock off, as it is called, and hence the stopping of one or more may cause others near them to stop also. This may in a measure be arrested by providing fly wheels at intervals on the line shaft, so heavy in their rim as to act as a constant retardant and storer of power, which power is given back upon any reaction on the shaft, and thus the strain is equalized. I mention this, as at the present time it is occupying the thoughts of prominent millwrights, and the relative advantage and disadvantage of light and heavy shafts is being discussed and is influencing the practice of modern mill construction.

I have mentioned the method of uniting bars of round iron so as to make long lines of shafting, in considering the theory of the coupling. I have given you an insight into the principles involved in a successful bearing for the shafts to revolve in, and I have dwelt a little on the shafts as regards size and velocity. I will now call your attention to the pulleys or band wheels. See Fig. 18. The best belts or bands used on these wheels are of leather, kept in good con-

FIG. 18.



dition by the judicious use of oil. Belts of leather are made of single thickness of leather for some purposes, and of two or more thicknesses for the endurance of harder strains. In general, main driving belts are made double thickness, and belts for transmission of power to machines, with some exceptions, are made single thickness. The terms double and single belts have come to be applied to leather bands in the trade, while India rubber belts, now quite extensively used, and often to advantage, have their grades indicated by one ply, two ply, three ply, etc., as indicating their thickness. It is of the utmost importance, for considerations of economy in running as well as first cost, that pulleys should be made as light as is consistent with strength. Pulleys that are to sustain the weight of double belts must be made heavier and stronger than those that are to sustain the weight of single belts; and the use to which the pulley is to be applied must influence its proportions. In the early practice of making cast iron pulleys, it was believed necessary that the arms should be made something like the letter S on the plane of the pulley. The idea was that they would be less likely to break from shrinking strains in the casting. It is quite evident, however, that a straight arm, such as one in the samples shown you (see Fig. 18), representing a straight line from the center to the circumference, will take the least metal; and I can state as a fact, after very long experience, that pulleys made with straight arms are the strongest, with equal proportions, provided proper precaution be taken in selecting the iron to be used in making, and regulating the conditions of cooling. The straight armed pulley can be made with the least possible metal and the greatest possible strength for the metal. Its form is the best able to transmit the peculiar strains brought to bear upon it, and at the same time it is the most pleasing form to the eye. In machinery, as in Nature, fitness to intended purposes has much to do with our ideas of beauty. The arms should be oval, so as to present the least resistance to the air in running, and they should be as light as is possible to make them, consistent with strength. This is of the utmost importance, as the weight of the pulleys on the line shafting often is very great, and this metal must revolve with the shafts, and its revolution costs in proportion to its weight. This cost of rotating the mass of metal is a constant cost irrespective of the work done, hence the need of carefully considering the weight and its reduction to the minimum. Pulleys should be turned truly round, and they should be cylindrical only in the case of belts having to be shifted sideways on their face; for stationary belts the pulleys should be made higher in the center, the curvature of the face being, say, ½ in. per foot. In trade, pulleys for stationary belts are termed "high," for shifting belts "straight," on the face. They should be also very carefully balanced. This may be done by turning the rim outside and inside, or it may be done by attaching a mass of iron to the lightest side of the pulley. The former practice holds with large driving pulleys, the latter with the smaller pulleys on the line. Large driving pulleys, when over 3 feet diameter, should always be carefully fitted to the shaft, and be held from turning by a key fitting sideways, never bearing top and bottom. Very large pulleys, say for belts 12 inches wide and over, should be forced in the proper place in the shaft by a forcing press, in the same manner as I stated car wheels are fitted to their axles. The various transmitting pulleys on the line may be so bored as to slide on to their respective shafts and be held by set screws. Pulleys are now made in most large machine shops of so many sizes that they present the readiest means of regulating the speed of the machinery. Some establishments are filled with patterns varying by ¼" in diameter for smaller sizes, say under 12", then by ½ in. up to 18" or 20", and after that by one inch up to 3 feet, and by two inches up to 6 feet in diameter. This variety answers all the purposes of trade. Pulleys made smooth on their faces transmit more power than when rough, and are less destructive to the belts used upon them. The power that can be transmitted by a leather belt running on a smooth cast iron pulley is dependent upon the strain of the belt upon the extent of surface of pulley encompassed by the belt, and the direction that the belt is led to and from the pulleys; but a very safe approximate rule is to assume that every 1,000 feet of motion per minute of each inch in width will transmit one horse power with a single belt. This can be doubled by the use of double belts, but with more severe strain upon the journals. The subject of relative sizes and widths of pulleys, and the various conditions of belt direction, would in itself be enough to fill an hour's lecture, so I cannot enlarge upon it to the extent I would like.

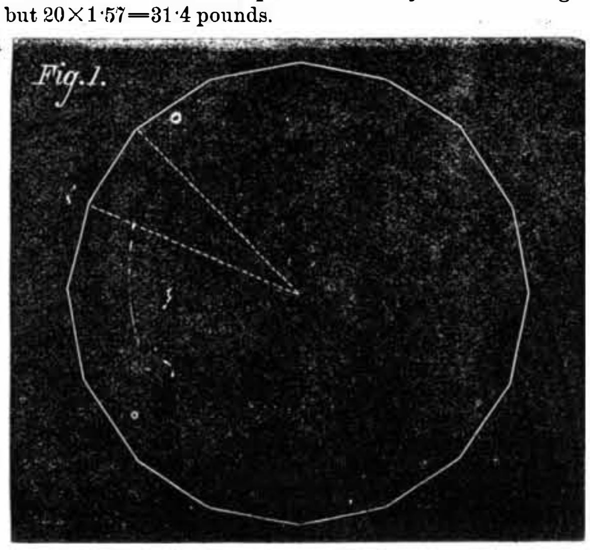
Correspondence.

The Editors are not responsible for the opinions expressed by their Correspondents.

Bursting Strain of Cylindrical Boilers.

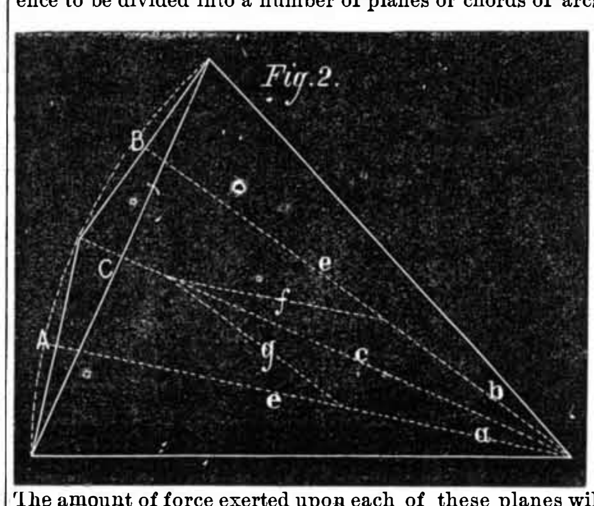
To the Editor of the Scientific American:

I generally get the SCIENTIFIC AMERICAN every week, but do not always have time to read all the articles contained in it. In looking over your number of October 19, 1872, a few days since, I observed an article, which I had not before seen, on cylindrical boilers: and as the conclusions at which your correspondent arrives seem to me to be very erroneous and calculated to mislead, I wish to offer a few remarks on what I think may be regarded as the true solution of the question. He states that the force tending to disrupt a cylindrical vessel by internal pressure is not as the diameter, but as the circumference; that is to say, with a boiler 20 inches in diameter, with an internal pressure of one pound per square inch, the strain upon the shell would not be 20 pounds for every inch of its length, but $20\times1{\cdot}57=31{\cdot}4$ pounds.



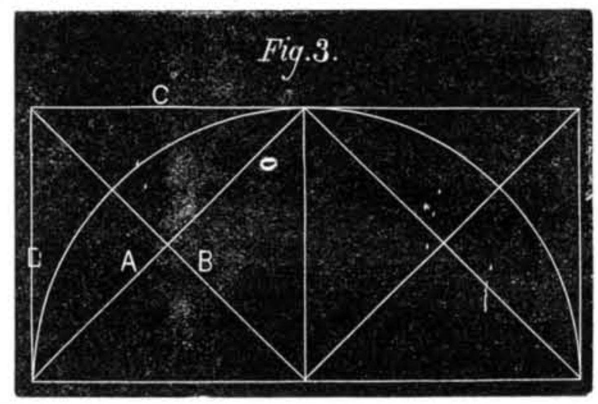
The process of reasoning by which he arrives at this conclusion is not stated; but it appears to have been given in some former articles. Let us then examine this question by the old fundamental law of the composition and resolution of forces, and see what is the answer which it gives to us.

Let us for the sake of illustration suppose the circumference to be divided into a number of planes or chords of arcs.



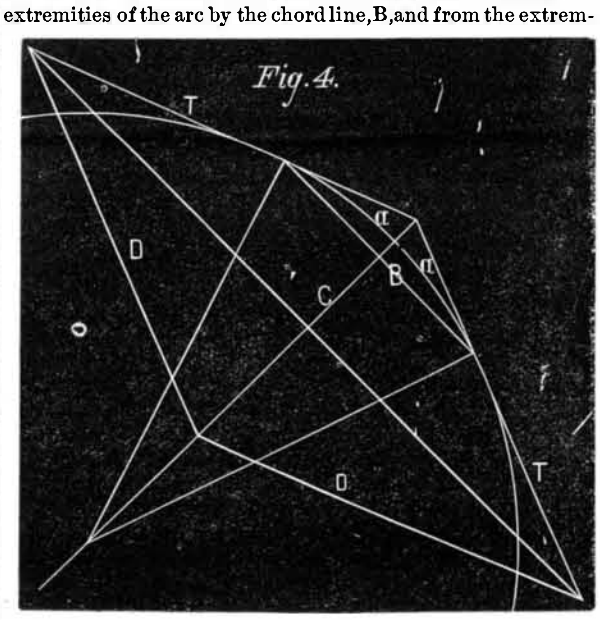
The amount of force exerted upon each of these planes will evidently be in proportion to its length; any two of these forces may therefore be resolved into one, and that force will be exactly equal to the chord of the arc inclosed by both the planes.

Thus A B represents two chords of equal lengths, and the dotted lines, e e, the direction of the force exerted upon them. Mark off a and b equal in length to A and B, and complete the parallelogram a b f g; and by the resolution of forces, the diagonal C of the parallelogram will equal the sum of the forces, and that will be equal to the length of the chord C. We have now found that the sum of the two forces on A and B is equal to the force on the chord, C, of the sum of the two arcs which they inclose. By taking another arc of the same length as C, we can in the same manner reduce these forces also to one, which will be equal to the chord of an arc twice the length of the arc enclosed by C. We can proceed in this manner until we have resolved all the forces into two inclosing arcs of 90° each; and these finally resolved into one will be found to be exactly equal to the diameter. Again, we shall find if we analyze these forces by the same rule that the strain on the shell of the boiler is the same on every part of the circumference, and that that strain is equal to the force due to the radius or half diameter. Take for instance the semicircle shown in the annexed diagram, in which the chord A rep-



resents the amount of force exerted upon the arc of 90° which it encloses, and the line B, the direction of the force and (being of the same length) also its amount. This force, B, will be held in equilibrium by the two forces represented by the lines C and D, each of which is equal to the radius.

Now take any other portion of the circle, and, by applying to it the same rule, we shall obtain the same result. Take any portion of the circumference as the arc, a d. Join the two extremities of the arc by the chord line, B, and from the extrem-



ities draw also the two tangents, T T. From the intersection of the tangent lines, mark off the line, C, equal to the length of the chord. B, and this line will represent the direction and force of pressure acting upon the arc a a.

From the end of the line, C, draw the lines, D D, parallel to the tangent lines, T T, which complete a parallelogram of which C is the diagonal, and which therefore holds in equilibrium the forces represented by the tangent lines T T, which tremities of the arc by the chord line B, and from the extremlines are equal to the radius of the circle. Any arc of the circle, greater or less, will give the same result. Thus we have a ready method of ascertaining the strain upon parts of boilers which are curvilinear in form, as we have only to find what would be the radius of the circle of which such curve forms a part; and that will give the amount of strain it endures. S. S.

New York city.

Prevention of Fires.

To the Editor of the Scientific American:

The Boston calamity, like that of Chicago, will doubtless bring out a vast number of suggestions, some wise and some otherwise.

It seems to be agreed that the fire in this case originated from the steam engine used to operate the elevator; and the flames, being drawn up the elevator shaft, were at once communicated to the Mansard roofs, which were of wood and beyond the reach of the fire engines.

This has called forth a vast deal of denunciation of the Mansard roof, which is all very well, so long as people will build them of tinder, and out of the reach of engines. But it seems to me that people, in their anxiety to condemn these roofs, have overlooked a much more important matter, and that is the danger and folly of locating steam engines in buildings, in the reckless manner that is now practiced in all