[From Journal of the Franklin Institute.]

TRANSMISSION OF MOTION.

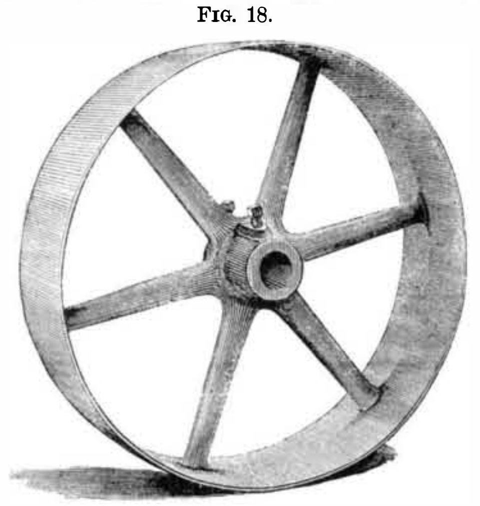
A Lecture delivered by Coleman Sellers, at the Stevens Institute of Technology, Hoboken, N. J., February 19th, 1872.

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 ½" 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.

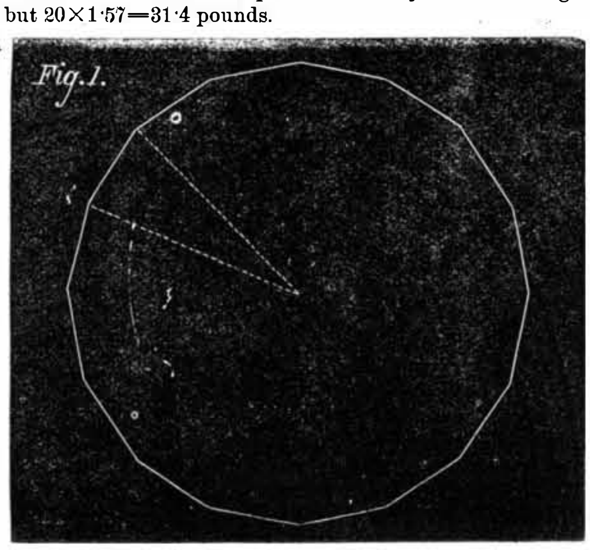
Correspondence.

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

Bursting Strain of Cylindrical Boilers.

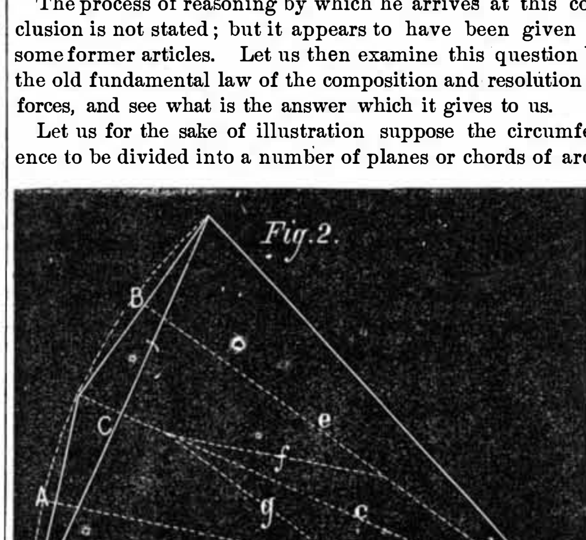
To the Editor of the Scientific American:

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 $20 \times 1{\cdot}57 = 31{\cdot}4$ pounds.



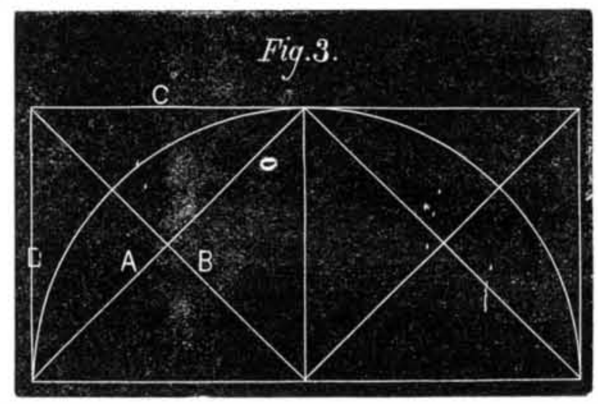
The process of reasoning by which he arrives at this conclusion is not stated; but it appears to have been given in some former articles. Let us then examine this question by the old fundamental law of the composition and resolution of forces, and see what is the answer which it gives to us.

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



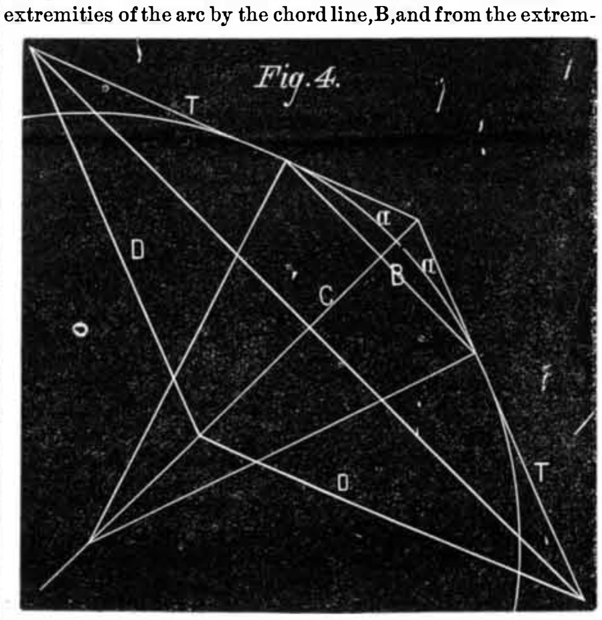
The amount of force exerted upon each of these planes will evidently be in proportion to its length; any two of these forces may therefore be resolved into one, and that force will be exactly equal to the chord of the arc inclosed by both the planes.

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 cities. Had it not been for the steam engine there would have been no fire; and it seems to me that it would be much more reasonable to condemn their use than to pitch into Mansard roofs so vigorously.

The amount of property and life annually destroyed in this country, by the use of steam engines, in the compactly built and settled portions of our cities is frightful. Now all this may be prevented by the substitution of either water or air engines for the steam engines. We have both, that are as perfect as steam engines and of are course perfectly safe. True, there is not provision for their use as yet, but that can soon be remedied. Let it once be settled, by law, that no steam engine shall be permitted in any thickly settled portion of a city, and provision will soon be made for the others, both water and air. As to water engines, they can be and are now used to a considerable extent, by simply connecting them to the city water pipes. Of course, the supply of water is not sufficient at present for their general adoption, simply because no such idea was contemplated when the water works were established, and no provision has been made for them. It is, however, a very simple matter to do this; and if there was a demand for it, created by prohibiting the use of steam engines, the supply would soon be furnished. Take, for instance, New York, Boston, Chicago, or any other large city; how easy it would be to lay water pipes for this special purpose, and force water through them by pumps! Sea water would do for this purpose, and the engine for pumping it could be located at any convenient point along the wharf. The water, after being used for the purpose of operating the engines, could then be used to sprinkle the streets, clean the gutters, slush the sewers, and for many other purposes, and thus improve the sanitary condition, while at the same time lessening the demand on the regular water supply for such purposes, which in most cities is fast becoming deficient. There is no doubt that it would pay for any city to increase its water supply for the express purpose of furnishing power, charging a reasonable price for it. It is cheaper than steam power as at present used, and is infinitely safer. In those towns and cities where the Holly system has been adopted, all that is required is to increase the pumping capacity, as the present pipes will answer. If it were intended at the outset to do this, it would be better to increase the size of the pipes, or perhaps have a separate set for that special purpose.

Compressed air may be used in the same manner, but not so well, because it is far more difficult to confine, as it will escape where steam will not; and it is far more difficult to keep the air pumps in working order. One advantage of the air would be better ventilation of shops and buildings, as the escape air might be utilized for this purpose; but I doubt whether it would be of as much use, in a sanitary point of view, as the water.

It seems to me that if "an ounce of preventive is worth more than a pound of cure," this is a remedy well worth our notice. I have no doubt the time will come, when we shall have power conveyed, all through our principal cities, for manufacturing and shop purposes in this way, more especially for all the lighter kinds of work, elevators included; but to effect it, the use of steam must be prohibited.

Washington, D. C. W. C. DODGE.

The Vienna Exhibition.

To the Editor of the Scientific American:

In the presumption that you desire to be correct in your statement of facts in connection with the American department of the Exhibition, will you permit me to point out certain errors in your editorial of November 30?

You say that "In a widely distributed circular issued *from General Van Buren's office*, we find the following remarkable statement: The Austrian government is exceedingly desirous that the United States shall be well represented, and makes *extraordinary concessions* to American manufacturers. The Austrian patent law is practically abrogated for the six months following, and inventors are protected by a special ordinance against piracy of their inventions." Now, sir, the circular from which you have taken this extract I find, upon enquiry, was published by Professor Thurston, of the Stevens Institute, at Hoboken, and bears his name and address in full. It was never issued from this office, nor does it purport to be.

The expressions commented on are perhaps a little stronger than may be warranted, and yet it remains true that concessions have been made and that patents are granted without cost to exhibitors, to be in force during the Exhibition and for two months afterwards. In all my statements upon the subject, I have endeavored to give a careful and true account of what had been done for the protection of our inventors and of what I was striving to accomplish. I have never hesitated to say that the policy of the patent laws of most European countries was piracy and not protection, but I have claimed that the disposition of the Austrian authorities in connection with the proposed Exhibition was to modify existing statutes, so as to protect inventions sent to Vienna from this country.

In referring to the treaty upon trade marks, I have never claimed any connection with it, but have spoken of it as being a step in advance and as evidencing a more liberal spirit. So, too, with the law which permits an exhibitor to take out without cost a certificate which operates for the time as a full patent. I admit, and have always done so, that these are not sufficient, that the obnoxious feature of the Austrian patent law, which compels the manufacture of the article in Austria within one year from date of patent, remains. And I have striven to obtain a treaty removing or modifying that provision, not "by simply sending a draft to Washington," as you allege, but by months of correspondence with the proper authorities of both countries and by visiting Washington to urge speedy action. And I have faith to believe that favorable results may be looked for; but I must be pardoned for judging that the violent opposition of some portions of our press and threats of ruining the prospects of our American department at the Exhibition—if they have any effect—will serve to postpone or prevent the success of my endeavors.

You say again that I have appointed sixty-five assistant commissioners. By what authority, may I ask, is this statement made? Not one fifth of that number have yet been appointed; and they are scattered about in some of the larger cities of the Union, and are engaged in distributing programmes of instruction, giving explanations and receiving and forwarding applications for space, etc.

In regard to an appropriation, I propose to ask that the expenses of a certain number of commissioners be paid, not to exceed a limited sum; and that these commissioners shall give their time and labor to the duties of their positions. A proportion of this commission will be composed of some of our most distinguished scientific men, who will thoroughly examine and report upon all parts of the Exhibition.

I propose also that the Government shall bear the expense of receiving, storing, shipping, freightage, and placing all goods sent to the Exhibition and returning them, of fitting up the American department, of the rental of space, of the construction of a model school building, of the necessary office work and rental in this city, and all the absolutely necessary attendant expenses. If this is refused, of course the Exhibition, so far as we are concerned, will fail, in which failure I shall be but little more concerned than any other citizen; but as a citizen, I should deeply regret such a disgrace produced by such causes. THOS. B. VAN BUREN,

United States Commissioner for the Vienna Exposition of 1873.

[For the Scientific American.]

ASTRONOMICAL NOTES.

OBSERVATORY OF VASSAR COLLEGE.

[For the items of meteorological and astronomical observation and for some of the computations in the accompanying notes, I am indebted to students.

The times of rising and setting of the planets are for the latitude of Vassar College, and are approximate only, no account having been taken of refraction or dip of the horizon, the aim being to furnish to everyday readers the means of recognizing the planets, and of following them in their apparent daily motion from east to west.—M. M.]

The following notes are from the records of the Observatory of Vassar College, from November 1 to 15, 1872:

THERMOMETER AND BAROMETER.

Highest thermometer at the time of recording was
at 2 P. M., November 1......................59°
Lowest thermometer 7 A. M., November 5.........25°
Highest barometer 7 A. M., " 5.........30·46 in.
Lowest " 2 P. M., " 7.........29·57 in.

The highest wind was from the northwest, November 12, at 9 P. M.

QUANTITY OF RAIN.

	Inches.
November 3	0·07
" 5 and 6	1·25
" 12	1·675
" 14	0·365
Amount November 1 to 15	3·36

SUN SPOTS.

The spots on the sun have been very numerous, and some of them very large. On November 5, five groups were seen by the aid of a glass of low power. One of these groups was very much extended across the disk. On the 7th, this had stretched along for more than half a diameter, and, on the 10th, was easily seen with the eye (protected, as it always should be, by smoked glass). On the 11th it seemed to reach its maximum; on the 16th, it was still to be seen, although the sun's motion on its axis had carried it nearly out of sight. Even with a low magnifying power, more than thirty individual spots could be counted in this remarkable group. They must have been formed rapidly, as the record of November 4 makes no mention of unusual agitation. At this date (November 16), spots of good size are coming on, and will probably be seen for some twelve days.

OCCULTATION.

November 10, at 7h. 55m. 38·9s. the moon occulted, or seemed to pass over, the star 30 *Piscium*, a star of the 5th magnitude. As the moon was not full, its dark limb seemed to approach the star, which disappeared instantaneously as they met.

POSITIONS OF PLANETS FOR DECEMBER, 1872.

MERCURY.

Mercury passes the meridian, or souths, at 1h. 20m. December 1, and at 10h. 27m. on December 31. On the 1st of the month it sets after the sun, about a quarter before six, and on the last of the month it rises before the sun, a little before 6 A. M.

VENUS.

Venus (at this time, November 16, so brilliant in the southwest), sets on December 1 at 6h. 44m., and on December 31, at 5 minutes before 7.

MARS.

Mars is very small, but can easily be known by its ruddy light. It rises December 1, about half past one in the morning, and keeps nearly the path of the celestial equator, setting about half past one in the afternoon. On December 31, Mars is much further south, being 4° north of the bright star *Spica*.

JUPITER.

Jupiter, the most interesting of all the planets, rises at this time (November 16) about midnight; it is becoming more and more favorably situated for observation, and on December 1 will rise a quarter before eleven, and on the 31st, before nine in the evening.

The best time for observing any planet is when it souths; Jupiter souths, or comes to meridian, in the early morning hours all through December, but it is in northern declination, and in this latitude has a good elevation some hours before meridian passage. By the last of December, it can be well seen in the evening. It is in the constellation *Leo*, between *rho* and *gamma Leonis*, nearer to *rho*.

JUPITER'S SATELLITES.

The four moons of Jupiter can be seen with a glass of low power, and their transits, occultations and eclipses, which occur very frequently, render the observations of this planet intensely interesting. The shadow of the largest of these moons will be thrown upon the face of the planet after midnight on the 21st, appearing generally as a round, black spot. The 4th satellite, which is next to the 3rd in size, will be eclipsed on the 24th and will emerge from the shadow of Jupiter at 11h. 47 m. 48s., Washington time.

Seen in large telescopes, the belts of Jupiter are continually changing, and are, some reddish and mottled by dark and white spots, some dusky and broken into irregular stripes.

SATURN.

Saturn is no longer well situated for observation. It is among the stars of *Sagittarius*, and sets at 7h. 11m. on December 1, and at 5h. 29m. on the 31st. Its ring can be seen with a glass of low power.

URANUS.

Uranus is in the constellation *Cancer*. It rises on the 1st about 8:30, P. M., and is well situated for observation. An ordinarily good telescope will show its disk. It comes to meridian at 3h. 50m. on December 1st, and 1h. 49m. on December 31,

NEPTUNE.

Neptune is in good position, but a very good glass is needed to show it to be a planet. It rises on December 1 at 2h. 19m., comes to meridian, or souths, before 9 P. M. (8h. 46m.), and sets a little after 3 A. M.

The Great Pumping Engine in Chicago.

An immense pumping engine has lately been completed and successfully operated in Chicago. It is of 1,200 horse power, and consists of two machines connected by a single shaft. The two steam cylinders are each 70 inches in internal diameter and allow a 20 feet stroke of piston. The steam chests are provided with double puppet-balanced valves, and the unhooking gear is arranged so that both engines may be controlled at the front of either. The flywheel is 25 feet in diameter and weighs 33 tuns. With the exception of the great machine at Haarlem, Holland of which the diameter of the cylinder is 12 feet and stroke 10 feet, there is probably no larger pump in existence.

During the past year Chicago has laid nearly 20 miles of water pipe; which is more than has ever been placed in the city during a similar period.

Chinese Arithmetic.

The Chinese have a most ingenious method of reckoning by the aid of the fingers, performing all the operations of addition, subtraction, multiplication, and division, with numbers from 1 up to 100,000. Every finger of the left hand represents nine figures, as follows:—The little finger represents units, the ring finger tens, the middle finger hundreds, the forefinger thousands, the thumb tens of thousands. When the three joints of each finger are touched from the palm towards the tip they count one, two, and three of each of the denominations as above named. Four, five, and six are counted on the back of the finger joints in the same way; seven, eight, and nine are counted on the right side of the joints from the palm to the tip. The forefinger of the right hand is used as a pointer. Thus, 1, 2, 3, 4 would be indicated by first touching the joint of the forefinger; next the the hand on the inside; next the middle joint of the middle finger on the inside; next the end joint of the ring finger on the inside; and finally the joint of the little finger next the hand on the outside. The reader will be able to make further examples for himself.

Action of the Brain.

M. Fournié communicates to *Les Mondes* the following interesting experiment on the cerebro-spinal nervous system of animals. He says: "I wished to determine a process which would permit me to injure any portion of the brain without destroying life. With this view I made a small hole in the skull of a living animal by means of the instrument used in surgery for osseous sutures; then across this hole I introduced the needle of a hypodermic syringe (*séringue Pravaz*), and, at the point of the brain I wished to destroy, I injected a caustic solution, chloride of zinc colored blue. The part touched by the fluid was injured; consequently it ceased to fulfil its functions. After the subject had reposed, I noted the symptoms presented for some twenty-four hours and then killed the animal. I discovered readily the injured part by the induration of the tissues and the blue coloration. The experiments show plainly that simple perception resides in the optic couches (*couches optiques*), that distinct perception and memory require the integrity of the cortical periphery, and that the lesion of the circumvolutions is not accompanied by paralysis of the members but only by weakening." The author proposes to extend these experiments with a view of arriving at further important results.