the Caloric Engine in the Herald; some gentlemen on board also called it "the breathing ship." Mr. Stirling said, on page 565 and 566, London Mechanics' Magazine. "In an early patent (1827, his first,) he had specified the arrangement of the respirator, intending to use a series of *perforated plates or wire gauze.*" This was in print four years before Capt. Ericsson obtained his last patent. We quote fairly, and treat the matter candidly, giving our authorities, so that any person can examine for himself, and see that we set down nothing but truth—truth long known to us, but with which our newspaper editors cannot be supposed to be acquainted,—on that very account they should have been more moderate in their language. So much then for the history of the hot air engine.

We have only to add that it was stated at the aforesaid meeting, that Stirling's hot air engine, of 30 horse power, had been in operation for two and a-half years, driving all the machinery of the Dundee foundry, and that the fuel it consumed was only 2½ lbs. of coal per horse power in an hour.

POWER OF THE ENGINES.—In the Caloric Ship, there are four working cylinders, each having 22,300 square inches of piston area (each single acting) and six feet stroke. The supply cylinders (air feed pumps) have each 14,794 square inches of piston area, and the same length of stroke. The horse-power of the caloric engines is set forth in the following extract from the "New York Herald," which was an answer to a correspondent of the "Brooklyn Eagle," and has been sanctioned by Capt. Ericsson as being correct. "Atmospheric air, enclosed in a tight vessel, and elevated to a temperature of 384 degrees, acquires, it is well know, a pressure of 12 pounds per square inch. This happening to be the working pressure of the engines under consideration, it will be quite easy to test the accuracy of the calculation of the scientific correspondent, by estimating the force of the working piston, and the resistance of the supply piston, each by itself. The latter deducted from the former will obviously exhibit the theoretical power of the engine. Now, each working piston of the Ericsson contains 22,300 square inches, operated upon by heated air of 10·96 pounds, mean pressure—the actual pressure of 12 pounds being reduced by cutting off at three-fourths of the stroke. The mean force of the working piston will thus be 22,300×10 96=244,408 pounds. The active space passed through by the four working pistons being 6×14×4=336 feet per minute, the active power developed will be 244,408×336=82,121,128÷33 000=246·88 horse power. The supply pistons, each containing 14,794 square inches, in compressing and forcing the cold air into the receivers, operate against a mean resistance of 9·34 pounds per square inch. The contracting force of these pistons will thus be 14,794 × 9·34×336=46,527,936÷33,000=1,409 horse-power, which deducted from 2488, leaves 1079 horse-power differential or effective force, losses by friction, &c., being disregarded. Make the liberal allowance of 479 horse-power for such losses, and 600 horse-power remains—a force sufficient to effect far more than the projectors of the Ericsson expect. Some time may yet elapse, it is reasonable to suppose, before the pistons, valves, &c., will be rendered air-tight enough to retain the internal pressure of the machine, which is so essential in bringing out its full power. ENGINEER."

There were many typographical errors in the Herald,"—we have corrected some of them, so as to state the question as fairly, as viewed by those interested in the "Caloric Ship." The above calculation however is not correct and we will endeavor to point out more than one error. We allow the 384° to be above the common temperature of the air, which if it is 40°+384°=424° it will not have a pressure of 12lbs on the square inch, but 11.731lbs. Air doubles its volume by an increase of its temperature to 491° according to the latest experiments of Regnault and Magnus, not 480° as Capt. Ericsson calculates, therefore when air is heated from 40° to 531° it will exert a pressure of 15lbs on the square inch thus 491°÷15=32·733, therefore 384÷32·733=11·731lbs. pressure on the square inch, not 12lbs.

The horse power of an engine, is equal to the average pressure on the piston in pounds per square inch multiplied into the velocity of the piston per minute, divided by 33,000. The calculation of Engineer, is not therefore correct, for the air feed pump only allows a certain quantity of air every stroke, and no more; it is not like the steam engine, having a reservoir of power in the boiler; for the pressure of the steam is as the quantity, and so it is with hot air. The pressure then of the hot air in the working cylinder, is not 12 lbs. nor 11·731 lbs., but about 7½ lbs. on each square inch. The large cylinder, although it has 22,300 square inches area, surely cannot be filled with more air each stroke than the capacity of the feed cylinder, if it were, it must be fed in by some hidden *extraneous steam engine.* Well as 384° of heat is imparted to the quantity of air fed in by the feed pump, we will have a pressure equal to 11.731 upon each square inch of 14,794 piston area, but even allowing the pressure to the 12lbs. on the square inch, the average pressure on the working cylinder will be 14,794×12÷22,300=7.956 pressure on the square inch of the working piston, it has 312 ft. 670 in. of greater cubic capacity; for as is the difference of capacity in the feed pump and working cylinders, so, is the pressure reduced by the expanding. The power of the engines are as follows: 22,350×7.95×54÷33,000=290×4=1160, for the power of the four cylinders. We give 54 ft. per minute as the velocity of the piston, or 9 revolutions of the shaft per minute, as we counted them on the trial trip. Now what power do the engines expend in working the pumps; namely an average pressure of 9.34lbs on the square inch of 14,974 inches area of piston, therefore 14,974×9.34×54÷33,000=228.857 h.-p.×4=915.428—1160 h. p.=244.572 or nearly 250 horse power which the engines have to spare to drive the paddle wheels. We make no allowance for the cut off, for the feed is entirely different from the steam engine; it is forced in, and the quantity of air fed in is the only data for calculation along with the heat imparted.

The power required to feed must be very great, for as the molecules of cold air expand while passing through the Regenerator they exert a back pressure in proportion to the heat they imbibe. What then is the value of the Hot Air engine in comparison with the steam engine? It is in its very nature, owing to the element it employs (hot air) very inferior. Its motion must be sluggish for at every stroke, 616 cubic feet of cold air must be heated to 384° and the faster cold air is passed over a heated surface, the slower it takes up heat.

In the steam engine, for every 1728 cubic feet of steam, it only requires one cubic foot of cold water fed into the boiler. The Caloric Engine consumes nearly all the fuel used upon itself; it is not so with the steam engine. It has been stated that the Caloric Engine only consumes 1 lb. of coal per horse-power per hour; its speed was no more than seven miles per hour by the Coast Survey measurement; therefore, to double its speed, it would consume eight times more fuel, as calculated by engineers, this is half a pound more per horse-power than the Arctic uses, which has made 18 miles per hour in smooth water.

It is said to be more safe than the Marine Steam Engine; but when did we ever hear of a *steam ship* using low pressure steam, bursting her boiler. The steam engine is a safe machine, under the charge of good men, and so is a ship without steam or hot air, but not otherwise.

We would welcome hot air, as a superior and more economical motive power to steam, if it really were so, but it is not. The same amount of fuel applied to a boiler to produce steam from water, will produce a greater mechanical effect than if applied to air, which is a very bad conductor, and absorbs heat so slowly that it must always be sluggish in its motion. A steam engine can be built—boilers and all, which will give out triple the power of the Caloric Engines to the main shaft, and occupy less room. The combustion of fuel in the Caloric Ship is very perfect, and deserves credit, but the amount of leakage must be very great every stroke, as a portion of the fed air must always be lost, and it will be very difficult to keep the pistons air-tight. We therefore cannot have any other belief than that the "Caloric Ship Ericsson" will not be successful.

We have used no scoffing language, nor have we such a spirit towards this enterprise.

In speaking of the fuel, we have allowed 6 tons of coal per day for the Ericsson, with 600 horse-power engines. We have nothing to add to the remarks we published on page 141.

Machinery and Tools as they are.—Geared Wheels.

(Continued from page 147.)

No branch of machinery, probably, has received more valuable assistance from mathematical science than that which formerly was known more especially as "Mill-work," but which is now generally designated by the title that forms the heading of this article. What were the uncouth and almost ludicrous-shaped wheels of the past race of millwrights may be conceived on inspecting the mechanical works of the last century. While the beautiful symmetry of their construction as at present made, is well known to all who are in any way employed about machinery. Not that the machinists of past times were less ingenious than their successors, but they worked mostly at random, unaided by the light of science, whose followers, at that period, spurned for the most part, the researches of any knowledge that could not, strictly, be classed under pure mathematics. A more liberal and enlightened spirit, however, has at length prevailed, and many of the most illustrious disciples of Newton have since, like him, been practical philosophers. More especially with regard to geared wheels have their studies been found of inestimable advantage to mechanics, as all can testify who have heard of Professor Willis, or who have availed themselves of his theory for the construction of toothed wheels. But, as the study of theories is often neglected, and the theory itself sometimes too intricate for the hasty seeker of information, we will here mention that the practical application of the above is to be found in a scale termed the "Odontograph," and which is extensively employed by machinists.

Before entering upon the shape of the teeth, it is worth while to enquire what are the mechanical laws affecting systems of geared wheels, which, if traced to their simple origin, are found in reality to be only a form of the compound lever, and that the conditions of equilibrium are the same. From the fact that the arms of wheels are as levers fixed at one end, and loaded at the other, and that, consequently, the greatest strain is upon that part of the arm next the axle, is derived the mode forming the arms strongest at the axle and tapering towards the rim.

In order that the power applied through the intervention of gearing may be used with the greatest effect, it is necessary that the wheel-work be properly designed and executed, otherwise power is expended to no purpose, and it should be especially noted that the primary object aimed at in the construction of toothed gear is the uniform transmission of the power, supposing that to be constant and equal. This implies that the one wheel ought to conduct the other, as if they simply touch ed in the plane passing through both their centres,—these considerations will show the importance of a right form of tooth for the wheels. Of the various methods which have been employed to determine the forms of teeth, that which is termed the epicycloidal curve, has been an especial favorite. This shape is produced by rolling a circle equal in diameter to the radius of the pinion upon another circle equal in diameter to the radius of the wheel, the diameters being taken at the pitch lines, which are the circles described by the wheel and pinion at their point of contact, the curves so struck, commencing at the pitch lines, form the points of the teeth. They are struck in opposite directions, the space between their starting points being the thickness of the tooth; and from these two points radial lines are drawn to the centres of the wheel and pinion, which forms the sides of the teeth included between them, within the pitch line. This form, it will be observed, made the tooth smallest at the root by the convergence of the radial lines, and consequently tended to weaken it; this was remedied in the pinion by casting a plate upon the teeth, which, forming part of them, served not only to bind, as it were, all the teeth together, but to strengthen the body of the pinion, perforated and weakened by the axle passing through it. "The roots of the teeth" upon the wheel were strengthened by small angle pieces, for which space was found without the curved line described by the teeth of the pinion. Such teeth worked freely and equably together. But it will be observed that the side of each tooth of the wheel consisted partly of a radial line, partly of an epicycloidal curve, and partly of such a concave angle piece as might be found to clear the pinion: and it will also be observed that the wheel and pinion were adapted to each other; consequently another pinion, differing much in diameter from the first, would not act well with the same wheel. A mode of forming the teeth of wheels, by which this inconvenience is obviated, has been proposed by Professor Willis, and the form of tooth thus produced is much superior to the old-fashioned plan. If for a set of wheels of the same pitch a constant-describing circle be taken to trace those parts of the teeth which project beyond each pitch line, by rolling on the exterior circumference, and those parts which be within it, by rolling on the interior circumference, then any two wheels of the set will work correctly together. The describing or "Pitch Circle" should be equal in diameter to the *radius* of the smallest pinion, which, in this case should not have less than twelve teeth. When rolled upon the interior circumference of a circle equal in diameter to the pinion, a point upon the periphery of the pitch circle will describe radial lines through the centre of the larger circle representing the pinion, which is twice the diameter, so that the form of the pinion teeth within the pitch line may be at once drawn in straight lines from the centre. When rolled on the exterior circumference, epicyloidal curves, forming the teeth of the pinion beyond the pitch line are described by the tracing point. But when these operations are performed by rolling the pitch circle upon another of much larger diameter, representing the wheel, the interior and exterior epicycloids form a tooth of very different shape; it is no longer contained within radial lines, but spreads out at the root, giving great strength and firmness at the point where they are most needed. The exterior epicycloid forms the point of the tooth in a manner similar to that already described; but any wheel or pinion having teeth described by a common pitch circle will work together; even the teeth of a rack, which, being placed upon a straight line, may be regarded as the segment of a wheel of infinite radius can be formed in the same manner, and will work equally well with the wheels. The principles above discussed are applicable to both spur and bevel wheels; there is, however, another form in which teeth are shaped when the wheel and tangent screw principle is employed, and the thread of a cylindrical screw gives motion to a wheel, a plan which is often employed to diminish a high velocity.

(To be Continued.)

Long Tunnel.

One of the tunnels on the Pennsylvania Railroad now constructing, is to be 3,670 feet in length. Its area at the widest space within the lines of the masonry will be about 24 feet, and the spring of the arch will begin 16 feet from the crown of the arch. The arch itself, of the tunnel, will be rather of an oval form, one of the most beautiful curvatures which Conic Sections can afford. The greater part of the vast arched excavation will be inlaid with strong and substantial masonry. More than half of this masonry will be composed of sandstone well laid in hydraulic cement; and the remainder will be hard burnt brick. This whole masonry will be 22 inches thick.

The tunnel passes the Allegheny Mountain in Sugar Run Gap, and lies partly in Blair and partly in Cambria County. Taking into account the length of the Tunnel and its interior breadth, and the quantity and solidity of its masonry, it may be regarded as the largest work of the kind in the United States.—About 400 men are employed upon it.

The Seminole Indians have again entered into hostilities against the United Sttaes.