

The patentee's fourth improvement consists in constructing the axle-box and the axle in such manner that the lubricating material employed shall be retained in contact with the journal and the bearing, and thereby prevent a considerable portion of the waste which has hitherto taken place with axle-boxes as usually constructed. He constructs the axle of one piece or of two pieces, as in the usual way; the brass forming the bearing is properly fitted in, and the end of the axle is inserted into the axle-box from the back; the axle inside against the journal is turned with a flat or taper shoulder, against which is fitted and placed a metal ring; between the ring and the back of the axle-box is inserted a ring of vulcanized india-rubber, or other similar substance, thereby preventing the escape from the axle-box of any considerable portion of the lubricating material employed. The fifth improvement consists of a means of enabling any of the passengers in railway carriages of a train to signal and communicate with the engine-driver or guard, by the aid of electricity. To the middle partition of each railway carriage, near the roof, is fixed a small voltaic battery, by means of which the passengers are enabled to bring into action an electro-magnet, that explodes a percussion cap or rings a bell. —[*Enrolled, June 22, 1848.*]

Ibid, Aug., 1849.

MECHANICS, PHYSICS, AND CHEMISTRY.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

On the Paddles of Steamers—their Figure, Dip, Thickness, Material, Number, &c. By THOMAS EWBANK, ESQ., City of New York.

(Continued from page 60.)

The foregoing experiments and remarks relate chiefly to the *figure* and *dip* of paddles. Other traits next solicited investigation; and, though neither prominent, nor promising any adequate reward for the requisite labor, they were thought worth attending to, since engineers will certainly be urged shortly to cast about for every means of adding, though ever so little, to the speed of steamers.

Buoyant or Displacing Paddles.

It had been imagined, that the resistance which fluids oppose to the sinking of bulky bodies in them, might be employed as an element of propulsion—that if close barrels, for example, were fastened to the arms of a wheel, their ends would act as paddles, and the force required to plunge them, (equal to 62 lbs. for each cubic foot of water displaced,) also react favorably on the boat. To test this idea, eight square and tight boxes, 7 inches by 7, and 6 inches deep, were secured to the arms of one wheel, and set to work against the eight blades, No. 1, (fig. 3,) on the other. The boxes required, very sensibly, more power to carry them round than any other tried, and were miserably deficient in pushing the vessel forward with it—certainly not equalling four of the competing blades. They produced quite a commotion in the water, carried large quantities over with them, and,

could we have communicated sufficient velocity, would probably have formed a vertical ring of it. These boxes were, and should be, considered simply as unusually *thick* blades. All paddles are buoyant in proportion to their thickness.

Thickness of Paddles.

But though worthless in one respect, they were valuable in another, for they led us to the fact, or the law, that the propelling virtue of blades expands and contracts with their thickness. Thicken them till they touch each other, and they form a perfect drum, which could exert no more propelling power than a revolving grindstone;—reduce them to the thinnest plates, consistent with the strains they have to oppose, and in the same ratio that property is augmented in them.

The boxes were removed, and boards, $\frac{7}{8}$ ths of an inch thick, and 7 inches square, put in their places. These represented common plank paddles, and were found sensibly inferior to their metalline competitors, whose thickness was slightly less than $\frac{1}{16}$ inch. We next took away two of the latter, when no very obvious change in the boat's direction occurred. When two more were taken off, the remaining four were unable to contend with the wooden ones. These, it will be remembered, were $\frac{1}{4}$ th the thickness of the boxes, and consequently inherited that proportion of their defects.

It was also very observable how much more water was raised by the boards than by the plates. It could not easily be cast off their blunt boundaries, but kept running over them, from one side to another—a fact rendered more distinct in the boxes. Nothing could declare plainer, that the sharper the dipping edges of paddles are made, the more back water they throw off at the point where its departure is most beneficial: that is, when the re-action favors the vessel's progress—and, consequently, less is carried higher than the axis. A very little labor would impart this feature—in other words, would make their section a wedge. The resulting benefit would repay the expenditure a hundred fold.

Compared to metal, wood approaches in its nature to sponge; water clings to it; its pores are absorbing vessels, that suck it in, and assist to retain it on the surface.

Here nature also confirms the positions arrived at. Extreme tenuity of blade is stamped with perfection by her. Hence we see it strengthened by reticulated bars in the wings of insects—by radial, angular, and tapering, ribs in the fins and tails of fishes. An uniformly thick, and unsupported slab, like our paddles, is nowhere met with. We cannot imagine natatory or soaring organs, formed after such a pattern, without feeling the absurdity.

The caudal propellers of fishes are necessarily thick where they join the bodies, but how rapidly is the substance diminished, and to a mere film, at their extremities, so much so, that they are often there torn and jagged, by accident or wear, as fishermen well know. There must, therefore, be some powerful reason for withholding the material—one that overbalances all inconveniences resulting from its absence; and what can it be but the thinner the blade, the more efficient as a propeller it is—the longer is its stroke, and the more effectual is the power that wields it. The same law

prevails in the wings of birds; their outward boundaries are feathered off to almost nothing.

The reflection is irresistible. With what nicety and care Nature perfects her propellers, and how clumsy and unfinished are ours; as if, forsooth, a vessel's progress did not depend upon them!

The last two experiments demonstrate, that the less water a paddle *displaces* by its volume, the more efficient it is; that all accumulation of material behind its acting face, beyond what is absolutely necessary to strengthen it, is injurious, and ought to be avoided. But how does this accord with the current practice? Oak plank is universally employed, and I have heard more than one engineer assert, that the thicker they are the better! Because, said they, if their propelling property be not enhanced, it is not diminished, and their additional weight is a positive advantage, since the heavier the wheels are, the easier they work—the more uniform are their movements.*

The "Gorgon," an English steamer, had "large wheels and little power," so she used oak or pine scantlings, 5 inches by 6, or 6 by 8, for paddles. Had her managers been aware of the true effect of thick blades, they never would have adopted them with the view of economizing power.

Paddle planks vary in thickness from $1\frac{1}{2}$ to 3 inches. No sea steamers have them less than 2 inches. In the English vessels they are $2\frac{1}{2}$; in others, as the *Franklin*, they are $2\frac{1}{2}$; in some of the largest class they are 3. The *Atlantic* and the *Pacific*, each of 3000 tons, now building for the Collins' Line, are to have them 3 inches. The former is to have 28 blades; hence, united, they will form a solid mass, *seven feet* thick, in each wheel—just one-fifth of its diameter! They are to be $12\frac{1}{2}$ feet long, by 34 inches; those of both wheels will, therefore, contain nearly 500 cubic feet of timber, and must displace that enormous volume of water at every revolution, by their submersion alone!—and, as we have seen, not only uselessly, but with a serious retardation of the vessel's headway, and waste of her motive power.

The wheels of the *Pacific* are to be 36 feet in diameter; each will have 30 blades, $11\frac{1}{2}$ feet, by 3 feet; the solid contents of her paddles will, therefore, equal 517 cubic feet. Her loss from the same source will, therefore, be greater. In every revolution of *each wheel*, her paddles will lose $7\frac{1}{2}$ feet of effective stroke, and those of the *Atlantic* 7 feet! Those of the ocean steamer *United States* are $2\frac{1}{4}$ or $2\frac{1}{2}$ inches thick; they are 36 in number, but as they are "split," and attached on both sides of the arms, there are really 72. They certainly diminish the effective strokes of her blades, from 10 to 15 feet, in every turn of her wheels, startling as the assertion is.

Has the attention of engineers ever been turned this way? Or have they forgotten, that a volume of water equal to that of a boat's paddles, and every inch of material submerged with them, is neutralized as a resisting

*As a further indication that the value of thinness in blades, and of their disincumbrance from every pound of material extraneous to their functions as propellers, has not hitherto been appreciated, it may be remarked, that the same language was repeated in my hearing thus:—"A few tons of wood in the buckets do no harm, if they do no good; they add weight to the wheel, which is desirable, and their only disadvantage is, the additional load on the boat." I believe this is the general, if not the universal, opinion of engineers. But the experiments just referred to, teach us that, if a wheel require loading, the load should be attached to those parts of the arms that revolve above the surface. They cannot enter the water without becoming drags on the blades.

medium, as often as it is displaced by their immersion;—that water is to them what steam is to pistons—the more space the latter occupy in cylinders, the shorter becomes their stroke, because metal then takes the place of steam; the object to be moved crowds out the mover. Thicken a piston till it fills its cylinder, and the motive agent being wholly kept out, all motion ceases.

It is much the same with the paddles of a wheel. Let them fill up $\frac{1}{8}$, $\frac{1}{4}$, $\frac{1}{2}$, or $\frac{3}{4}$, of the circles they describe, and in those proportions they lose their virtue, because in the same proportion they displace, or push aside, the fluid agent on which their worth depends.

The *Atlantic* will lose *seven feet* stroke in every turn of her wheels. I leave to mathematicians to determine, how many more miles an hour she would make, if the loss were reduced to *seven inches*, by using $\frac{1}{4}$ -inch iron, in place of 3-inch plank.

There are several interesting questions about paddles that yet require solutions, but as respects their thickness, there is no *mean* to seek; the thinnest is the best under all circumstances—thin, were it possible, as a lamina of mica. The only question is, What material will supply the thinnest sheets to resist the pressure they are to oppose? Plates of steel, I opine, will yet be adopted.

To one remark, an examination of some steamers' wheels adds force.—The accumulation of bolts, nuts, clamps, straps, stays, and other things, on and about the backs and faces of paddles—sometimes even to bolting a new plank, or part of one, over an old one—show that those who heap on matters of the kind, are not aware now much the efficacy of blades are thereby diminished. They forget that they should be thin and smooth as plates of glass, and that every inch of matter introduced between them, is an evil. It is impossible to view the disjointed, broken, patched up slabs of some vessels, without exclaiming, "What a saving of power, and increase of useful effect, would not the substitution of a suitable sheet of metal for each accomplish!"

A new division of engineering, I sometimes think, might judiciously be made, and paddle-making be recognized as a distinct department. These instruments have certainly never received the attention which they merit. Speed is the great desideratum, and it depends on them. Engines, and all the mechanism of a steamer, are subservient to them, and yet, while everything else has been elaborated to the utmost, they have been all but overlooked.

In some vessels—the United States mail steamer *Galveston* is one—strips of plank are bolted over the ends of the paddles to prevent their splitting, or warping. As they do not diminish the faces, but merely form elevations upon them, they are doubtless considered as in no degree interfering with the propelling function. We now perceive that, when such things are necessary, they should be of iron, and let into the blades, so as to be flush with their surfaces.

Number of Paddles.

The experiments of each day convinced us that, so far as propulsion is concerned, the fewer the paddles, the faster went the boat, so long as *one* at each wheel, or an area equal to the face of one, was kept in full play.

A greater number in the water merely cuts it into slices, throws them into commotion and diminishes the resistance they should oppose to the blades. As a further elucidation of this fact, we tried, at the suggestion of Mr. B., four blades, 7×14 , against the eight test ones, 7×7 . The smaller number had a decided advantage over the greater, and the cause was visible: they had a full sweep, through an unbroken, undisturbed, mass of fluid, and consequently produced, unabridged, their legitimate effects; while those on the other wheel—unusually small ($\frac{1}{2}$ or $\frac{1}{4}$) as their number was, compared to those on the wheels of steamers—following so quickly in the wake of one another, threw it into an uproar, causing eddies, whirlpools, and counter currents, and thus interfering with each other, necessarily produced inferior results.

We thought 8 of fig. 4 would be equally valuable as 24 of fig. 3, but the construction of our wheels prevented us from instituting a series of similar comparisons.

The number of paddles now employed is, generally, greater than formerly. For large vessels, 28 are usual; some have 24, and others 32. The English rule, said to be a good one, is adhered to by many American engineers, except when circumstances require a deviation. By it, there is a paddle for every foot of a wheel's diameter, which makes them stand three feet apart; there are boats in which they occur every two feet.

One object of their multiplication, is to equalize the jar of their striking the water, by increasing the number of the blows. With the same view, they are often split through the middle, lengthwise, and the inner half—that next the shaft—removed to the opposite side of the arm, as in the end view, fig. 26, thus *doubling*, in a manner, their number. All the British steamers have their blades thus arranged. The *Hermann's* 28 were thus made into 56; their efficacy was found to be reduced about 9 per cent. The value of the upper or inner halves has been ascertained to be about the same, for, when wholly removed, the lower portions have proved within 10 per cent. as effective as before. The blades of the *United States* are split, and disposed as in the figure. The true principle of breaking the jar of paddles striking the water, seems to me to be indicated in the blades 4, 5, 8, 9, 10, 14, 15, 21, 22, 23, 24, 25. Had the attention of engineers been led to it in the early days of steaming, the popular plan of avoiding the evil at the expense of a greater, would not have been sanctioned so long.



I observed the blades of the last named steamer, a week after her recent return from Europe. *Seven* were submerged, or *fourteen*, if those on both sides of the arms be counted. She sailed on the 4th inst., for New Orleans, with eight (or sixteen) under water. The *Cherokee* left on the 1st inst., for Savannah, with *six* of her undivided blades below the surface. The *Washington* came in on the 6th inst., from Bremen, with *five* similar ones fully immersed on each side—four full ones, and the halves of two others. The largest of our Sound and River boats have equal, if not greater numbers under. The *Vanderbilt*, 1200 tons, has *five*, or *ten* halves, immersed in each wheel, when lying at her dock, and without passengers on board. The *Isaac Newton*, 1200 tons, has similar wheels, and the same number of blades under water at once.

It is clearly as impossible for a paddle to do its duty, when thus embarrassed among its fellows, as for a traveler to make the same progress through a crowd, as on an open plain.

27 As sea steamers have little occasion to go stern-forwards, the backs of the acting faces are occasionally dressed off, as shown by the outline of fig. 27. As far as the lower, or dipping, parts are concerned, this is an advantage; but, from the preceding experiments, it is seen how much more beneficially such blades would act, were those parts brought to a knife-edge, and their sections bounded by the dark part of the cut.



Arms of Wheels.

The practice of making the arms of paddle wheels of uniform, or nearly uniform, dimensions throughout, is also wrong. They may, without diminution of strength, be reduced towards their extremities, and ought to be, since every inch of surplus material submerged in them, detracts from the work done by the blades. They should taper outwards, as Nature tapers the radial ribs in her propellers.

Coating Paddles with Materials that Repel Water.

If any substance can be found, durably to prevent paddles from being wetted, they would then carry over less water with them. We coated one set with grease, (suet,) and, while the water streamed uniformly over the faces of others, it adhered only in narrow streaks to these.

Besides the paddles described, some others were tried, but, as they involved different principles, and were not of very practical application, their introduction here is not necessary.

These results sustain but partially, the views expressed in the article inserted in a former number of the Journal.* The form of blade there proposed removes but one evil. The value of those figured on page 267, Vol. xvi., can, from data here given, be readily ascertained.

The lessons which the foregoing experiments teach us are:—

That, to render paddles of steamers more effectual, they ought to be fashioned, as far as circumstances sanction, after models furnished by Nature, so as to conform to her general practice of contracting surface when resistance is of little avail, and extending it when the latter is greatest—to give the largest portions of blades the longest strokes.

That the fewer the paddles on a wheel the better, provided one be always kept in full play;—and hence, that it would be more advantageous to point, or fork them, as proposed, to evade the jar of their striking on the surface, than so perniciously to split and multiply them, as the popular practice is.

That smooth and thin metallic plates should be substituted for the usual massive, water-soaked planks. (At present, perhaps, nothing better than boiler-plates, galvanized, could be adopted.) That bolt-heads, nuts, cleats, straps, and every other projection, upon, or about, them, should be provided against. That the arms of wheels ought to be reduced at their outer extremities, and the immersion of all superfluous material carefully avoided. That, when wheels require balancing, or their momentum to be increased, the weights should be attached to the arms above the surface of the water.

* Journ. Frank. Instl., Vol. XVI, p, 264.

To coat paddles, and parts that plunge with them, with varnish, or other substance that repels water, that the fluid, instead of being dragged up in volumes by them, may roll from them, as from the backs of diving birds.

Some persons smile at the idea of machinists studying nature; and such, on perusing the preceding suggestions, will deem it a sufficient reply, to remind the proposer, that steamers are not blackfish, nor paddles salmon's tails, nor petrels' feet.

But minds differently organized, think a glance into her workshops is never amiss, and that the longer the visit, the better for the visitor, since there is no art or contrivance, (and it is certain that, through eternity, there never can be one,) which has not its prototype in her collections. If we find them not, it is because of inattention, or of an imperfect acquaintance with her stores. Perhaps we know not at which of her ateliers to inquire, or are not prepared to appreciate specimens laid before us when we enter.

No person, of course, expects to find in living mechanisms, exact copies for artificial articulations; but when a mechanical principle, and the instruments through which that principle is manifested, are before us—when we see motion communicated to a class of organs, comprehend their construction, effect of their forms, modes of their action, and dynamic results—there is no difficulty in making such deviations, as difference in materials, powers to be employed, and conditions under which the artificial machine is required to act, may require. It is the perfection of invention thus to *imitate* Nature—the maturity of science and art to tread in her steps.

It would be wrong to close this paper, without acknowledging many obligations to Mr. John Bell, of Harlem, by whose assistance the experiments were conducted; a gentleman whose judgment on general mechanics is not surpassed; and to Mr. Mott, for the use of a boat, and facilities for making the various paddles tested; to Messrs. Morris & Cummings also.

Mr. Bell has matured a substitute, which he proposes for paddle wheels, consisting of two reciprocating arms on each side of a vessel. At their extremities are folding blades, or vanes, which open when sweeping in one direction, and close in the other. He dispenses with the cumbrous paddle boxes, and leaves the deck nearly clear;—at the same time increases the sweep of the blades beyond what is practicable with wheels, by simply elevating (on framework resembling that of beam engines) the points of their suspension.

From Mr. Allaire, and from Mr. Stillman, the well-known principal of the "Novelty Works," were derived many valuable facts.

New York, November, 1848.

Note.—Since the above paper was written, I have seen in the Journal of the Franklin Institute, for February, 1842, (3d series, vol. 3, p. 102,) an extract from the Civil Engineers' and Architects' Journal, for October, 1841, by which it appears that Mr. Rennie was led, by his experiments, to substitute the diamond-shaped paddle (fig. 8) for that of the ordinary form. It is there stated, that, "after a great variety of experiments, he found that a paddle wheel of one-half the width and weight, and with trapezium floats, was as effective in propelling a vessel, as a wheel of double the width and weight, with the ordinary rectangular floats." This agrees very well with my own results. (See p. 45.) Mr. Rennie states that the

Admiralty had permitted him to fit H. M. ship *African* with these wheels, and he had perfect confidence in the success of the experiment; but I have not been able to find any account of the results of this trial upon a large scale.

Measures have been taken to secure by patent, the improvements developed by the preceding experiments.

TRANSLATED FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

Account of the Experiments to determine the Principal Laws and Numerical Data, which enter into the Calculations of Steam Engines. By M. V. REGNAULT.

NINTH MEMOIR.

On the Latent Heats of Saturated Vapor of Water under Different Pressures.

(Continued from page 60.)

The object of this ninth memoir is to determine the quantity of heat which it is necessary to give to 1 kilogramme of water at 0°, to convert that water into saturated steam under different pressures. These quantities of heat are expressed by M. Regnault in terms of the number of kilogrammes of liquid water which they would heat from 0° to 1° Cent. We have kept these numbers, except in the final table. There we have added a column expressing the same results in degrees Fahrenheit.

Dr. Black was the first to observe the phenomenon of the absorption of heat during the conversion of water into steam, and he even attempted to measure it. The number he obtained was 530; a number much too small, because he did not take the necessary corrections into account. (*Lectures on the Elements of Chemistry*, vol. 1.)

The celebrated Watt made experiments at several different times upon this subject. The first attempts were made in 1765, and gave him the number 766, which he himself regarded as incorrect. He resumed the subject in 1781, and performed the experiments which he describes in the article *Steam* of Robison's *Mechanical Philosophy*. The mean of 11 determinations gave him 625·2, which he regarded as too small, and adopted, as more probable, 633·3.

Rumford sought for the same element by means of his calorimeter, (*Biot, Traité de Physique*, tom. iv, p. 710,) and found the numbers 669, 670·8, 671·9.

Dr. Ure published in the *Philosophical Transactions* for 1818, p. 385, a memoir in which he proposes to determine the latent heats of vaporization of a certain number of volatile substances. The number he obtained for water boiling under atmospheric pressure was 637·5; but it must be remarked that, as M. Brix has already remarked, (*Poggendorff's Annalen*, vol. lv, p. 351,) his results were calculated by an incorrect formula, and when this is corrected, the number deduced from these experiments is 593·4.

In this memoir, Dr. Ure states that Lavoisier and Laplace had found