

economy, and, above all, the safety of the boats, would be vastly increased.

But there is another means of overcoming the difficulty, and of increasing the economy of these packets, viz: the employment of condensing engines, which would at once cut down the requisite initial pressure 12 to 14 pounds per square inch, and by lessening the work of the boilers, permit a more perfect combustion of fuel. And although prejudice has done its utmost to prevent, or rather to postpone, in that section of the country, this improvement, high pressure engines will as certainly be driven from the Western rivers, at some future day, as they have been from the Lakes within the past few years. Their use on Lake Erie, which was formerly the *rule*, forms now a bare exception.

For the Journal of the Franklin Institute.

On Marine Propulsion. Reply to J. V. MERRICK, Esq. By J. W. NYSTROM.

Mr. Merrick's "*clear case*" resembles so much the turbid water of a swollen stream, that we think it must pass through the filterer of criticism, taking for our compound the *Static* and *Dynamic momentum*.

The first point to be tested will be found on page 271. In the first paragraph, Mr. M. states that if the above is not "clear enough he will state it in another form." *No, it is not clear.*

Let the arrows *m, n, o*, figs. 1 and 2, plate V, represent the direction of motion of the centre of the paddle wheels on a steam vessel, *w, w, w*, being the load line and water in which the paddles act.

The accompanying diagram plate V, represents two different situations of the vessel. Fig. 1, the paddles take hold of a rock in the water, so that the vessel can move freely without touching the rock; then there will be no slip of the paddles, while the vessel moves the space H. Fig. 2. The paddle acts freely in the water, so that while the vessel moves the space H, the paddle moves backwards the space V, which then will be the slip. Suppose the vessel moves the same space H in a unit of time; then if slip causes a loss of effect, more power should be required in fig. 2 than in fig. 1.

First Case, Fig. 1.—The crank of the steam engine is supposed to be in the same line as the acting paddle; then the line $R + r$ will be a lever of the second kind, with its fulcrum against the rock at *c*. The letters will denote:—

r = radius of the crank.

h = pressure in the crank pin.

b = velocity of the crank pin.

R = radius of the paddle wheel.

B = resistance in the centre line of the paddles.

H = velocity of the vessel.

c = resistance against the rock.

| | | | |
|-------------------|---|---|--------------------------------|
| Static momentum, | . | { | Action ($h + c = B$ reaction. |
| | | | $B : h = (R + r) : R.$ |
| | | | $b : H = (R + r) : R.$ |
| Dynamic momentum, | . | { | $B : h = b : h.$ |
| | | | Action $h b = B H$ reaction. |

Second Case, Fig. 2.—The crank pin moves the space W while the paddle moves the space V . There will be found a point, c , on the paddle arm which has no motion, and is therefore a fulcrum thereof.

I = pressure in the crank pin.

W = velocity of the crank pin.

B = resistance in the paddle journal.

II = velocity of the vessel or journal.

M = resistance of the water.

V = velocity of M .

c = resistance in the fulcrum c ; and

$$I + c = B \quad \text{of which} \quad B = I + c. \quad (1.)$$

$$I : c = S : r \quad \text{"} \quad S = \frac{I r}{c}. \quad (2.)$$

$$V : W = s : (S + r) \quad \text{"} \quad s = \frac{V (S + r)}{W}. \quad (3.)$$

$$s M + B S = I (S + r) \quad \text{"} \quad s M = I (S + r) - B S. \quad (4.)$$

By the insertion of the formula (3) in (4), we obtain—

$$M \frac{V (S + r)}{W} = I (S + r) - B S.$$

$$M V = \frac{I (S + r) - B S}{\frac{V (S + r)}{W}} = \frac{I W (S + r) - W B S}{S + r} = I W - \frac{W B S}{S + r}. \quad (5.)$$

By the insertion of the formulæ (1) and (2) in (5), we obtain—

$$M V = I W - \frac{W I r (I + c)}{\left(\frac{I r}{c} + r\right) c} = I W - \frac{W I r (I + c)}{I r + c r} = I W - I W \frac{r (I + c)}{r (I + c)}$$

that is to say, $M V = I W - I W = 0$. Or, $M V$ is no part of $I W$.

We see now that $M V$ is of no effect at all for propelling the vessel; it only serves to keep the paddle arm stationary at the fulcrum c , and if we examine $M V$ without any theory, we will find that the resistance M acts *with* the vessel, but the velocity V acts *opposite* the same, and they thereby counterbalance each other, and produce *no* effect for propelling the vessel.

Let the velocity of the paddle at the circumference be J , and V a fraction thereof. The effect exerted in the water should be $M J V$; but if we carry $M J V$ to the fulcrum it will be equal to 0, because $V = 0$, and there it will act as a resistance in marine propulsion, as the rock in fig. 1, with no effect. Then we have another lever of the second kind, with its fulcrum in c , which we will compare with the first case, fig. 1.

Fig. 2:—

$$\begin{array}{lcl} \text{Static momentum,} & \left\{ \begin{array}{l} \text{Action } I + c = B \text{ reaction.} \\ B : I = (S + r) : S. \\ W : H = (S + r) : S. \end{array} \right. \\ \text{Dynamic momentum,} & \left\{ \begin{array}{l} B : I = W : H. \\ \text{Action } I W = B H \text{ reaction.} \end{array} \right. \end{array}$$

$$\text{But} \quad B H = h b.$$

$$\text{Therefore} \quad I W = h b = B H \text{ which was to}$$

be proved.

We see now that the effect given in both fig. 1 and fig. 2 is equal,

and what the velocity in the one case is greater than in the other, the pressure will be so much less, because it acts on a shorter lever. To compare this with screw propellers, let the letters represent—

$R = P$ pitch of the propeller.

$S = (P - s)$ as in the paddle wheel.

Then we have $W : b = S : P$.

With equal velocity of the vessel, the different values of the pressure W is measured by $S = (1 - s)$ and caused by different areas of propellers. (See further respecting acting area of propellers.)

The appearance of loss of effect by slip is measured by the mass of water forced backwards;—it can be viewed in another way. Suppose a vessel runs in a canal say 1000 feet long, and has a sectional area equal to 10 of the propeller, whose pitch is 10 feet; then, when the propeller has made 100 revolutions, the vessel should run the 1000 feet if there was no slip. But suppose the slip to be 50 per cent.; then when the vessel reaches the other end of the canal, the propeller will have made 200 revolutions: that is, 100 revolutions which have propelled the water backwards; consequently, at the other end of the canal there should be no water left for the vessel to float in. But it will be found that when the vessel has passed the 1000 feet, the water is at the same height as when the vessel started from the first end. So it will be with a vessel starting from Liverpool for New York,—on reaching New York, the water will not be higher in Liverpool or lower in New York, extracting the tide. At the moment that a vessel starts, the slip is equal to the unit; if it is a measure of loss of effect, the vessel could never be started.

Mr. M. says, “And then the ratio of the coefficient * * * to the velocity of the water backward.” Now, after Mr. M.’s lengthy disquisition, “that slip is no loss of effect,” he comes to the conclusion of my first formula: $p v = r s$, or, as Mr. M. expresses it, $p : r = s : v$, in which

p = coefficient of the vessel.

r = area of floats multiplied by the coefficient for resistance to plane surfaces.

v = velocity of the vessel.

s = velocity of the water backwards (slip).

This is a proof that slip is *no* loss of effect. The effect delivered from the steam engine $r s = p v$ the useful effect.

After Mr. M. has embodied the formula, he condemns it as wrong, and says it should be $p = r$.

If Mr. M. had substituted *resistance* of the vessel instead of *coefficient*, it would have been all right. But this “coefficient” makes the remainder of his article wrong.

In his note Mr. M. says, “By the coefficient of a vessel, I mean that, * * * or 1 nearly.” Here Mr. M. is confused in the difference between effect and pressure. When a body, P , is to be moved from its passive state, and has no other resistance than its own inertia, the *pressure*, B , which is required to give that body a certain velocity, V , in a given time, T , is

$$B = \frac{P V}{g T} \quad \dots \dots \dots (1.)$$

But the *power* which is required to give the same body the same velocity in the same time, is

$$BH = \frac{P V^2}{g T}. \quad (2.)$$

D = total distance which the body has moved in the time T , and

$$\text{Pressure } B = \frac{2 P D}{g T^2}. \quad (3.)$$

$$\text{Effect } BH = \frac{2 P D}{T}. \quad (4.)$$

To apply this to vessels, we must first suppose the vessel P to have no other resistance against BH but its own inertia; then BH would give the vessel P the velocity V in the time T , and if at the end of the time T the pressure B be taken away, the vessel would still continue with the velocity V until some resistance acts opposite her direction; but as a vessel has the additional resistance of the *water* to sustain, the effect BH will not be sufficient to give the vessel the velocity V in the time T ; we therefore will find another value of BH . The letters will denote—

R = resistance of the water at the velocity V .

r = mean resistance of the water in the time T .

The effect which is required to the resistance of the water in the time T will be—

$$\text{Effect} = \frac{r D}{T}. \quad (5.)$$

This must be added to the formula (4), so that

$$BH = \frac{2 P D}{T} + \frac{r D}{T} = \frac{D (2 P + r)}{T}. \quad (6.)$$

We see here that even in the time T the effect BH is, independent of g = 32.08.

$$\text{The time will be } T = \frac{D (2 P + r)}{B H}.$$

At the end of this time T , the vessel has obtained the velocity = V , the resistance of the water = R , and the equation (4) will be = 0. Then the effect which is required to keep the vessel at the velocity V will consequently be $BH = R V$.

We see now that the effect which propels a vessel, a uniform velocity is entirely independent of the moving mass P , and the acceleratrix g , and that the resistance R , depends on the greatest section area of the displacement, friction area, and form of the hull. The square of the velocity multiplied “by the cubic feet of water” in motion, is a measure of the effect which has given the mass of water that motion, and *not* a measure of number of pounds.

Mr. M. says: “But the projecting area acting * * * multiplied by the secant, * * * is the advance of the vessel during a revolution.”

It is well known that resistance to planes in motion in fluid, can be less by moving the plane at some angle, more or less than 90° to the direction line; but I did not know that it could be greater than itself, as will be the case when multiplied by a secant, which is always greater than one. The area Mr. M. multiplies, can be increased and diminished *ad libitum*, in the same diameter of propeller. But when Mr. M. finds his secant, he adds two squares together and divides the sum by a square;

he calls that a secant = 1.40; that must be a secant = 1.40 *square radius*; then I suppose the corresponding angle will be *square degrees*! But if Mr. M. extracts the square root of his equation, he will obtain a true secant for the angle described, but then it will be my formula *turned upside down*, which makes it all wrong. It is the formula Mr. M. has condemned, and entitled "empirical."

The area Mr. M. calls 108 square feet, is only 65, and multiplied by the secant, it will be about 91 square feet.

Further, Mr. M. says, "the pressure constantly exerted by * * * is entirely independent of the velocity by which the vessel moves," = a given pressure in the steam cylinder can produce different velocities of the vessel! On which side of the equation does Mr. M. carry the circumstances? Next, as regards the acting area of the propeller, he says, "It appears to me, however, to be neither of these; but the projected area by the ratio of length between the helicoidal path traversed by the centre of effort, &c.;" if we apply this to our proposed test, it will come out, the more pitch in proportion to the diameter, the greater the acting area of the propeller should be.

This is entirely opposite to the fact. It is a fact that, propellers with more pitch and slip, employ the effect better for propelling, (if they do not exceed $n = \frac{200}{P \cdot S} \sqrt{D}$ revolutions per minute,) but there is another reason, namely: *that a less acting area has a greater velocity, and that the resistance to the same is in proportion as the square of its velocity, and that the friction in the water is in proportion as the acting area.*

I will here add a formula on which this acting area should depend.

Letters denote—

| | |
|-----------------------------------|---------------------------|
| A = acting area of the propeller. | (less than $0.785 D^2$.) |
| D = diameter " " | (extreme.) |
| P = pitch " " | |
| C = circumference " " | (at the diam. D.) |

$$A = \frac{2.5 D^3}{\sqrt{P^2 + C^2}}$$

This formula forms a part of the one given for finding the slip. The divisor $\sqrt{P^2 + C^2}$ is a secant for an angle whose tang. = P and radii = C. When I can, I rather avoid trigonometrical expressions, but *simply* this will be, *multiply* the area of the propeller by the *sine* for the angle of the propeller blades to the axis at the periphery; the product should be the acting area.

Mr. M.'s theory is, *divide* the projecting area of the propeller blades by the *sine* for the same angle, when the pitch is the advance of the vessel during one revolution, the quotient should be the acting area of the propeller; expressed in a formula without trigonometry, it will be—

$$A = \frac{D L m \sqrt{P^2 (1-s)^2 + C^2}}{4 P.}$$

C = a circumference taken at the centre of effort of the blades.

L = length of the propeller.

m = number of blades.

s = slip in a decimal fraction.

MARINE PROPULSION.

Fig. 1.

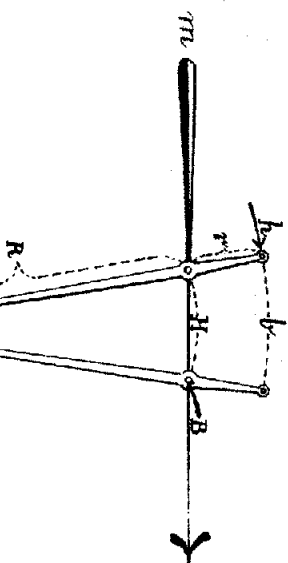
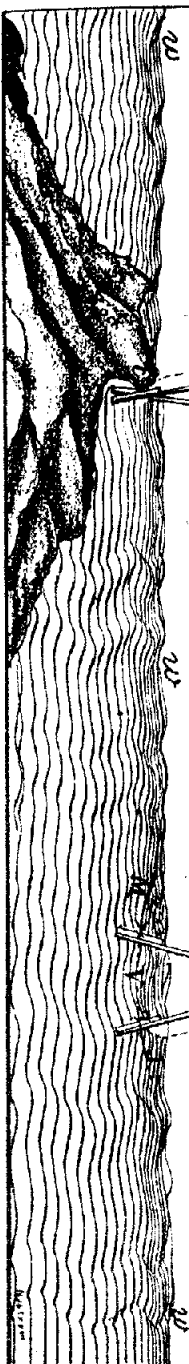
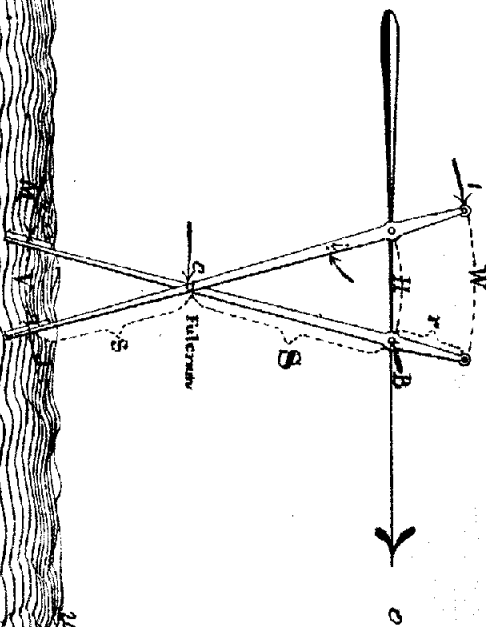


Fig. 2.



These four quantities have certainly something to do with the acting area, but they are not at all a measure of the same; they can vary considerably with the same acting area. But, the projecting area of the cylinder described by the propeller, multiplied or divided by some coefficient can not vary at such ad libitum. It appears to me, Mr. M. has mistaken the propeller for a paddle wheel, where his rules would be more likely to be applicable.

Mr. M.'s remarks about "action and reaction," I will not contradict, as I may be somewhat mistaken in the expression; but I will here explain how I understand it: action and reaction = pressure and resistance in *statics*. But in *dynamics* action and reaction = power.

When Mr. M. finishes his theory, he says: "such are the indications of theory, but it is found that the values given by them are but approximate." How is it possible that a theory composed of such incongruities ever can reach approximation? It is often the case that such a theory is applied in practice, and gives a wrong result, *then theory in general* is blamed. However, Mr. M.'s theory will surely do no harm in practice, because it is applicable *first*, when the work is finished. "And that there are some modifying circumstances experienced in practice." We cannot expect a result to come out nearer than the circumstances are carried, and Mr. M. says himself that "circumstances are generally on one side of the question."

After Mr. M. has repeated my statements based on Mr. Isherwood's error, he says: "The whole structure of the argument is built upon sand." Yes, sir, but I am not the builder; Mr. Isherwood first designed it, and applied it to the *San Jacinto*, and I made remarks upon it, stating it to be wrong, &c., &c.

But after all, I cannot find where Mr. M. proved my misapprehension in the first principles of dynamics; he says that the first equation "should have been $p = r$; consequently the results attained by it are valueless;" that is no proof at all, to say this is wrong; "consequently," *not right*.

For the Journal of the Franklin Institute.

Steam Boiler Explosion in New York.

One of the boilers of the extensive sugar refinery of Messrs. Howell, King & Co., Duane street, New York, exploded early in the morning of the 12th of April, at the moment of starting the engine. There are four boilers in the set, each 6 feet in diameter, 40 feet long, with one flue 42 inches diameter; thickness of iron used in the shell, $\frac{5}{16}$ -inch, and in flue, $\frac{3}{8}$ -inch. The furnace is within the flue, at the front end. This form of boiler is the kind generally used with Cornish engines, and is capable of resisting a heavy pressure of steam.

In the present case, it will be observed by fig. 1, which gives a longitudinal section of the boiler, that the top of the flue, at the front end, has been torn from the head of the boiler, and crushed nearly to the bottom. At the back head no fracture is visible, but there is evidence of severe strain. Fig. 2 is a cross section of the boilers at the front; and fig. 3 a