THE OBSTRUCTION TO THE NAVIGATION OF RIVERS CAUSED BY THE PIERS OF BRIDGES.

BY J. W. SPRAGUE.

We have now reached this result—the condition of a steamboat attempting the ascent of a draw is similar to that of a body ascending an inclined plane, whose length (l) is equal to the length of the boat, and whose hight (b) is equal to the hight of *remou*. The velocity (v°) of the water, through which the ascent is made, is the arithmetic mean of the original velocity (v), and of the increased velocity (V), so that $v^{\circ} = (v + V) \div 2$.

If we drag a weight up a stationary inclined plane whose length is l, and height, b, the power expended will be just equal to that required to move the weight through the horizontal distance, l, and then lift it vertically through the distance, b. Let the inclination of the plane be so slight that the friction of the weight is sufficient to prevent it from sliding down. No power is expended until we attempt to move the weight up the plane; to keep the weight just where it is requires no power.

Next, suppose that the *inclined plane has a motion of its own*; the direction of this motion being downward, and lying in the line of the plane; the velocity of this motion being such, that in one second every point of the plane will be carried *horizontally* a distance v°. Hence v° will be its horizontal velocity, but will be as much less than its actual velocity, as the base of a right-angled triangle, whose length is l, and whose perpendicular is b, is less than its hypothenuse. Under this supposition, and no power being expended upon the weight, at the end of one second the body will have moved with the plane through a horizontal distance v°, and will have descended through a vertical distance, $v^{\circ}\ (b \div l)$. If, then, a sufficient power had been expended merely to keep the weight from moving, the measure of that power would be a power sufficient to move the weight through a horizontal distance, v°, and to lift it through a vertical distance, $v^{\circ}\ (b \div l)$. It will be observed that this is the measure of the power required every second, merely to hold the weight in its original position, and is entirely additional to the power required to advance the weight up the plane. The position of a steamboat ascending a draw is similar to that of the weight just described as resting upon an inclined plane, which **is moving in a direction opposite** to the motion of the boat.

The measure of the power required to overcome the resistance arising from the *horizontal* motion of the boat and the current may be neglected at present, in order to determine the measure of the power required to overcome the resistance arising from the *vertical* motion of the boat and the current. Let W represent the weight of the boat in pounds; t, the number of seconds occupied in making the ascent. The power required merely to resist the vertical motion of the inclined plane each second will be a power sufficient to lift the weight, W, through the vertical distance, $v^{\circ}\,(b \div l)$. Hence $W v^{\circ}\ (b \div l)$ feet pounds is the measure of this power for each second of the ascent and $t\ W v^{\circ}\ (b \div l)$ the measure for the whole ascent. To this, which is merely the power required to keep the boat still, must be added the power required to raise it vertically from the lower to the upper level, which is $W b$; making the whole power (P) required—

$$P = W b + t\,W v^{\circ}\ (b \div l).$$
$$P = W b\,[1 + (t\,v^{\circ} \div l)]$$

This same result may be arrived at by another process. If, as before, t represents the number of seconds consumed in making the ascent, or in passing over the horizontal distance, l, then the velocity of the ascent will be $l \div t$; and the difference of velocity between the ascending boat and the descending plane, or the relative velocity of the plane to the boat, will be $v^{\circ} + (l \div t)$. The complete vertical resistance overcome each second will be the tendency to move W downward through the vertical distance $[v^{\circ}+(l \div t)]\, b \div l$. The measure of the power required each second to overcome this resistance will be $W\,[v^{\circ} + (l \div t)]\, b \div l$. As this power is exercised during t seconds, the whole vertical power (P) expended during the ascent will be $P = t\,W\,[v^{\circ} + (l \div t)]\, b \div l$, which, being reduced, gives $P = W\,b\,[1 + (t v^{\circ} \div l)]$. This is precisely the same value of P, as found by the first analysis. It will be remembered that this value of P does not embrace the power required to move the boat *horizontally* forward, with the velocity $v^{\circ} + (l \div t)$, which is the relative horizontal velocity of the boat.

An examination of the above formula shows that P increases with the increase of t, and diminishes in value with the diminution of t. Hence, so far as vertical resistances are concerned, the quicker the ascent is made, the less power is required. If the inclined plane was a stationary one, the amount of power required for the ascent would be entirely independent of the time occupied in the ascent.

For future illustration, take a Mississippi river steamboat of the following dimensions:—Length, 240 feet; greatest immersed section, 160 square feet; displacement, 30,000 cubic feet; weight of steamboat and load, 1,875,000 pounds. Such a steamboat has to ascend a draw where the original velocity of three miles per hour is increased to five miles per hour. What amount of power is required to overcome the vertical resistances of the ascent, for the different values of t; $t = 0$; $t = 10$ seconds; $t = 20$ seconds, &c.?

The case where $t = 0$, which is, of course, an impossible one, corresponds merely to a neglect of the motion of the inclined plane. A velocity of three miles per hour increased to five miles per hour is a velocity of 4.4 feet per second increased to 7.3 feet per second, which gives for the hight of *remou* $b = 0.58$ feet. Here $W = 1{,}875{,}000$; $b = 0.58$; $v^{\circ} = (4.4 + 7.3) \div 2 = 5.85$; $l = 240$.

When $t =$	0	$P = 1{,}087{,}500$	feet	pounds.
" $t =$	10 sec.	$P = 1{,}352{,}578$	"	"
" $t =$	20	$P = 1{,}617{,}656$	"	"
" $t =$	60	$P = 2{,}677{,}968$	"	"
" $t =$	120	$P = 4{,}268{,}436$	"	"
" $t =$	180	$P = 5{,}858{,}904$	"	"

33,000 pounds raised one foot high per minute, or 550 pounds raised one foot high per second is the measure of one horse-power, which is expressed as 550 feet pounds per second. Changing the preceding values into another form—

when $t = 10$	P. per sec. $= 135{,}258$ ft.lbs	$= 246$	$H.P.$
" $t = 20$	80,883 "	$= 147$	"
" $t = 60$	44,633 "	$= 81$	"
" $t = 120$	35,570 "	$= 65$	"
" $t = 180$	32,549 "	$= 59$	"

The values just given in horse-powers are upon the supposition that all the power of the engine is transmitted to overcoming resistances, without any loss from the *slip* of the wheel, friction, &c. These losses will be **taken into account afterwards, when it will be seen that the values just given must be considerably increased.**

We are now prepared to take into account the additional power required to overcome the *horizontal* motion of the steamboat—an element of the investigation which has thus far been omitted. As previously stated, the measure of the power required to move an ascending boat will be the sum of its velocity, added to that of the current; so that a boat ascending at the rate of five miles an hour against a current of three miles an hour will be considered equivalent to the same boat moving at the rate of eight miles an hour in still water. Experiments have shown quite conclusively that for ordinary velocities of steamboats the power expended in their motion *per hour* varies as the *cube* of the velocities, and the power expended *per mile* varies as the *square* of the velocities. We have to use the element of time, which is involved in the term "horse-power," not the element of space; hence we consider the power as varying with the cube of the velocities.

The actual (not nominal) horse-powers required to move the steamboat already alluded to, at different velocities, may be taken as follows:—

3	miles per hour or	4.4	feet per second,	8	Horse-power.
4	"	5.8	"	19	"
5	"	7.3	"	37	"
6	"	8.8	"	63	"
7	"	10.3	"	100	"
8	"	11.7	"	150	"
9	"	13.2	"	220	"
10	"	14.7	"	300	"

These values are probably not strictly correct, though determined according to the best data in my possession, they are used merely for illustration. Intermediate values can be determined by simple interpolation. These values contain an allowance for slip of paddles, friction, &c. In the preceding illustration, we have seen that the equivalent horizontal velocity of the steamboat when ascending the inclined plane of the *remou* was $v^{\circ} + (l \div t)$; when $t = 60$ sec. $v^{\circ} + (l \div t) = 9.85$ feet per second.
$t = 120$ " " 7.85 "
$t = 180$ " " 7.18 "

Hence for the power required to overcome the resistances to the horizontal motion we have—

when $t = 60$ seconds $= 89$ Horse-power
$t = 120$ " 46 "
$t = 180$ " 35 "

Combining the power required to overcome the horizontal resistances with the power previously found requisite to overcome the vertical resistances, we have for the total power required to carry the steamboat, up through the draw—

when $t = 60$ sec., total power $= 170$ Horse-power.
$t = 120$ " " 111 "
$t = 180$ " " 94 "

If, on the other hand, we had regarded the resistances as measured by the power required to move the boat horizontally, with the velocity $V + (l \div t)$ [*i. e.*, the maximum velocity of the current in the draw, *plus* the actual velocity of the boat], in addition to the power required to lift the boat vertically from the lower to the upper level, we should have by similar processes—

when $t = 60$ sec., total power $= 133 + 33 = 166$ $H.P.$
$t = 120$ " " $= 75 + 17 = 92$ "
$t = 180$ " " $= 59 + 11 = 70$ "

Indicating errors of 3, 17 and 25 per cent in the values; the true errors are really much greater, as will be shown further on, when the effect of friction and the slip of the wheel in increasing the power necessary to overcome the vertical resistances is taken into account.

[To be continued.]

DISCOVERIES IN THE COMPOSITION OF GUMS.

M. Fremy has lately presented to the Academy of Sciences of Paris a most important paper upon the "Chemical Composition and the Production of Gums." A few days ago, if any chemist had been asked—what is gum? or—taking the purest variety known—what is gum arabic? he would probably have answered that it is a peculiar, immediate principle of the vegetable kingdom, soluble in water, containing no azote, and belonging, seemingly, to the group of ternary substances, which comprises sugar, starch, cellulose, &c. M. Fremy's researches have, however, thrown a very novel light upon the subject. Gum arabic is not a neutral, immediate principle, like starch or sugar, but a salt, composed of a base (lime), united with a very weak acid, which the author calls *gummic* acid. Gum arabic is, then, properly speaking, gummate of lime. By the influence of heat, or by that of certain concentrated acids—such as sulphuric acid—this gummic acid is transformed into a new insoluble substance, which is also an acid, and which, having the same chemical composition as the former, constitutes an isomeric variety of it; to this new substance the name of *metagummic* acid has been given. Gummic acid, and its insoluble isomeric variety—metagummic acid—contain about 41 per cent of carbon, 6 per cent of hydrogen, and 53 per cent of oxygen. These interesting results will have, doubtless, also their useful applications, sooner or later; for when it is known with what ease gum and its derivatives can be transformed into isomeric substances which are insoluble, it is probable that it will one day be discovered how to employ gum like albumine, in dyeing and calico-printing, for fixing insoluble colors.—*Photographic News.*

SCIENCE AMONG THE BOYS.

MESSRS. EDITORS:—My brother lately took a small tumbler, filled it as full as he could with alcohol, and then filled the tumbler with cotton to the brim without spilling a drop of the alcohol. As my age is only 11 years I cannot give a satisfactory reason for the alcohol not spilling out when the cotton is put into the tumbler, though I have one which I believe is right. My reason is that the cotton is so porous that it absorbs all the alcohol, and the little that evaporates makes room enough for the real substance of the cotton. F. G.

Frankfort, N. Y., April 7, 1860.

[This explanation is undoubtedly correct. Boys ought always to be encouraged to make experiments like this for themselves. There is no other mode of education which is so impressive, so thorough, and especially so lasting in its effects. And it affords the very best discipline for the mind and character; teaching the child to test the assertions of the books by his own self-tried experiments, and to learn the interesting truths of Nature directly from herself. When James Watt pressed his finger upon the cover of his mother's tea-kettle to see if the steam pushed it up, he was learning a lesson more valuable than any he ever acquired at school.—EDS.