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

BY J. W. SPRAGUE.

In my last article, I alluded to the hight of the *remou* or back-water, but postponed the discussion of it. The present article I devote to that subject. Generally, the question of *remou* presents itself under this form:—If a certain obstruction is placed in a certain water-way, what amount of *remou* will be produced, when the water is at a definite stage, having a definite velocity in the uncontracted water-way? I know of no way of answering this question, except by the use of a long and quite complicated formula, one which it would be extremely difficult to adapt to any case other than the precise one for which it is calculated. Therefore, I prefer to change the question, putting it in such a form, as to admit of an easy answer, and one which is applicable to all cases:—What value of b, the hight of the *remou*, is required to change the velocity (v) in the uncontracted water-way above the piers into the velocity (V) in the contracted water-way between the piers? More simply, what hight of *remou* is required to increase the velocity, v, to the velocity, V?

Let h represent the head of water necessary to produce the velocity, v, per second; H represent the head of water necessary to produce the velocity, V, per second; and g (=32.22 feet) represent the acceleration of velocity produced by gravity in one second. Any elementary treatise on mechanics will give, as the theoretical values of the velocities, under such a case—

$$v^2 = 2\,g\,h \quad : \quad V^2 = 2\,g\,H$$

$$\text{or} \quad h = \frac{v^2}{2g} \quad : \quad H = \frac{V^2}{2g}$$

The hight of *remou*, b, is only the additional head required to increase the velocity v into V. Hence b is the difference between the heads, corresponding to the velocities v and V, or—

$$b = H - h$$

Substituting in this the values of h and H, as given above, we have—

$$b = \frac{V^2}{2g} - \frac{v^2}{2g} = \frac{1}{2g}(V^2 - v^2)$$

According to theory, then, the hight of *remou* would be the difference between the squares of the velocities divided by 64.44; but theory is not fully borne out by practice. The value $v^2 = 2\,g\,h$ or $V = \sqrt{2\,g\,h}$ is found to be too large by several per cent. The head corresponding to the velocity of any navigable river would not exceed three feet. For different heads, varying from three feet down, the actual velocity would only be about 96 per cent of the theoretical velocity; hence we should have $v = 0.96\sqrt{2\,g\,h} : V = 0.96\sqrt{2\,g\,H}$, or $v^2 = 1.84\,g\,h : V^2 = 1.84\,g\,H$; hence $h = v^2 \div 1.84g : H = V^2 \div 1.84g$; substituting these corrected values of h and H, in the value of b, already given, we have—

$$b = H - h = \frac{V^2}{1.84g} - \frac{v^2}{1.84g} = \frac{1}{1.84g}(V^2 - v^2)$$

reducing $b = .017\,(V^2 - v^2)$

This gives the rule for determining the hight of *remou*: *From the square of the velocity in the contracted water-way between the piers, deduct the square of the velocity in the uncontracted water-way above the piers; seventeen one-thousandths* (.017) *of the remainder will give the hight of the remou in feet.* The velocities used must be in *feet per second*. As an example under this rule:—What hight of *remou* is requisite to change a velocity of six miles per hour into one of seven miles per hour? Six miles per hour is 8.7 feet per second. Seven miles per hour is 10.3 feet per second. Using these values under the rule:—

$$b = \cdot017\,(10.3^2 - 8.7^2) = 0.52.$$

Hence a hight of *remou* of about ½ a foot or 6 inches is necessary to produce the required change.

The area of the cross section of any river, at the point where any bridge is to be erected, as well as the velocity of the current, for various stages of water, are to be determined by actual measurements. The plan upon which the piers are to be built will furnish a means of determining the amount of obstruction they will offer. Hence all these elements of the calculation may be regarded as known quantities.

A comparison of this article with the preceding ones will show that we have arrived at these results:—If we know the hight of *remou*, we can determine the increase of velocity in the contracted water-way. If we know the increase of velocity in the contracted water-way, we can ascertain the hight of *remou*. Here are two data, either of which being known, enables us to determine the other; but at the outset, we do not know either, and have no independent means of determining either. What then is to be done? Assume a value for the hight of *remou*, and upon that assumption determine the increase of velocity in the contracted water-way. Having now values for v and V, determine the corresponding hight of *remou*. This calculated value of hight of *remou* will not probably agree with the assumed one; but comparing the two together, it will be very easy to determine a new assumed value of height of *remou* more correct than the first assumed value. Using this newly assumed value just as the first assumed value was used, a third assumed value can be obtained more nearly correct than either of the other two. A few trials of this sort will give results sufficiently correct for all practical purposes, and having this advantage, that the limits of error can be readily determined, and that every additional trial brings us nearer to the truth. I am familiar with the formulæ given in the books for determining these results, but have no hesitation in saying that, for *any* and *every* case, I prefer the method I have pointed out to that given in the books. There are many cases (as, for instance, the one alluded to in the first article of this series) when the method of the books is totally inapplicable, but to which the method I have indicated may be easily adjusted.

As an illustration of this process of approximation, take the example given in the second article of this series, where we have the uncontracted water-way = 10,000 square feet; the obstruction caused by the piers up to the water-line 1,000 square feet; and the sum of the distances between the piers 900 lineal feet. Take the velocity in the uncontracted water-way at six miles per hour, or 8.7 feet per second. What will be the increased velocity of the current between the piers and what the hight of *remou*? Assume, at random, the hight of *remou* to be 0.3 of a foot. Then we have for the contracted water-way $0.99\,[10,000 - (1,000 + 900 \times 0.3)] = 8.643$ square feet, and for the increase of velocity, $10,000 \div 8.643 - 1 = 16$ per cent, giving the increased velocity $8.7 \times 1.16 = 10.1$ feet per second. What hight of *remou* is required to change a velocity of 8.7 to one of 10.1? $b = 0.017\,(10.1^2 - 8.7^2) = 0.45$. A comparison of the assumed value of b (0.3) with its value (0.45), as calculated under that assumption, shows the assumed value to be too small. As every increase in the value of b in the first formula will increase its value in the second formula, it is evident that the *true* value of b is greater than 0.45.

As a second assumption, take the value of $b = 0.6$. Then we have for the contracted water-way—

$$0.99\,[10,000 - (1,000 + 900 \times 0.6)] = 8.375$$

and for the increase of velocity,

$$(10,000 \div 8.375) - 1 = 19 \text{ per cent,}$$

giving the increased velocity, $8.7 \times 1.19 = 10.4$ feet per second, giving $b = 0.017\,(10.4^2 - 8.7^2) = 0.55$.

Comparing the second assumed value of b (0.6), with its value (0.55), as calculated under that assumption, shows this second assumed value to be too great. Since 0.43 is too small a value for b, and 0.6 is too great a value for it, the true value of b lies between these two, and the true increase of velocity is between 16 and 19 per cent.

As a third assumption, take $b = 0.5$. Then we have for the contracted water-way—

$$0.99\,[10,000 - (1,000 + 900 \times 0.5)] = 8.465$$

and for the increase of velocity,

$$(10.000 \div 8.465) - 1 = 18 \text{ per cent,}$$

giving the increased velocity,

$$8.7 \times 1.18 = 10.3 \text{ feet per second,}$$

giving $b = 0.017\,(10.3^2 - 8.7^2) = 0.5$

The third assumed value of b (0.5) agrees with its value, as determined under that assumption. Hence this third assumption is correct, and we have the actual increase of velocity 18 per cent, and the hight of *remou* half a foot or six inches.

Generally a sufficiently correct value can be arrived at by two or three assumptions, but sometimes more will be necessary. In the illustration just given, after the second assumption, we had assigned *limits within which the true values must be.*

The measure of the amount of resistance, encountered by a steamboat in attempting the ascent of a draw, will be discussed next week.

GLYCERINE FOR GAS METERS.

On page 149 of the present volume of the SCIENTIFIC AMERICAN, we published an extract from the annual report of J. C. Cressen, Esq., of the Philadelphia Gas Works, in which it was stated that he had been experimenting with glycerine (and with a very encouraging prospect) as the best fluid for gas meters, to prevent freezing in winter. Since that extract was published, our attention has been directed to an article read before the American Association for the Advancement of Science, at Baltimore, Md., in 1858, by Henry Wurtz, Esq., formerly professor of Chemistry in the National Medical College, Washington, and now of the Patent Office, in which he recommends the use of this fluid for such a purpose, and this appears to be the first published suggestion for such an application. We quote the following from his interesting paper on glycerine:—

"The common water meters, used for measuring the consumption of illuminating gas in houses, are open to two strong objections, namely: when in a warm situation the water rapidly evaporates, and when in a cold place it freezes. To avoid congelation, the usual expedient is to fill the meter in cold weather with alcohol or whiskey, thus rendering the first mentioned difficulty, that of evaporation, still more inevitable. Now what liquid do we possess which is practically free from these objections of evaporation and congelation? Evidently diluted glycerine. I propose, therefore, as a substitute for both water and alcohol for filling gas meters, *glycerine* (sufficiently diluted to prevent its absorption of more water from the gas, and increasing in volume to any important extent), thus rendering the meter independent of attention within the ordinary limits of temperature.

"For lubricating the bearings of fine machinery also, and particularly of chronometers, glycerine seems to me worthy of a trial, as it as unchangeable by the atmosphere, and remains fluid at temperatures which few or none of the oils will resist. For chronometers, pure oleine and oleic acid have been used, but the former thickens on exposure to the air, and the latter congeals at a few degrees below the freezing point of water. Other uses occur to me, such as in the preparation of copying ink, in water color painting, and in the preservation of dried plants for *herbaria* in a flexible state, mere allusions to which may at present be sufficient."

LOSS OF LIGHT BY GLASS SHADES.

A correspondent (W. King) of the London *Journal of Gas-lighting* gives the following table, made up from a series of experiments, of the amount of light lost by various shades:—

Description of shade.	Loss of light.
Clear glass	10.57 per cent.
Ground glass (entire surface ground)	29.48 "
Smooth opal	52.83 "
Ground opal	55.85 "
Ground opal, ornamented with painted figures, the figures intervening between the burner and the photometer screen.	73.98 "

As the large amount of light lost by the use of a clear glass shade excited some surprise, a sheet of common window glass was placed between the burner and the photometer screen, when it was found that 9.34 per cent of the light was intercepted, thus confirming the result obtained by the employment of a shade of clear glass. The shades were selected from a large number, and great pains taken to obtain an average specimen of each kind.

This is an interesting subject and opens a new field of inquiry to gas-makers and consumers. These investigations may throw some light upon the apparent difference of the illuminating power in gases and oils, on different occasions; the fault may be in the glass shades, not in the light itself.

POLITICAL ENGINEERS.—The Washington correspondent of the *New York Express* tells the following story which suggests a possible explanation of some boiler explosions:—A most laughable affair took place this morning. Mr. Forney has appointed a certain office-seeker to be assistant engineer at the Capitol. Several members were in the engine room, admiring the machinery, and one asked what was the *horse-power* of the engines? "Horse-power!" exclaimed the man with a round oath; "it ain't *horse-power*. IT GOES BY STEAM!" The members said nothing, except that he was honest; and, as there was some danger of his removalfor his well-known democratic principles, they wrote to Mr. Forney and requested him to retain so efficient an engineer.

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