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

BY J. W. SPRAGUE.

In the last number of the SCIENTIFIC AMERICAN, I spoke of the contracted water-way, or the water-way between the piers, as if it differed from the uncontracted water-way, or water-way above the piers, by merely the aggregate cross sections of the submerged portions of the piers and abutments. We are now prepared somewhat to qualify this statement. In order that the water passing between the piers may have greater velocity than the water at the head of the piers, it is necessary that the water should pile itself up above the piers, until the additional head thus produced is sufficient to give to the water the required increase of velocity to carry it between the piers. It is evident, then, that the surface of the water in the uncontracted water-way will be higher than the surface of the water in the contracted water-way. This difference of lever measures the hightof the *remou*, or back-water; we will represent it by *b*. To obtain a more correct value of the contracted water-way we must therefore deduct from the uncontracted water-way, not only the aggregate cross section of the piers up to the water-line, but also the product of the sum of the distances between the piers multiplied by *b*. To illustrate this, suppose a river 1,000 feet wide, and 10 feet deep to have 8 piers, 12½ feet thick, with vertical sides, located in it. Let the velocity of the current be such as to cause the obstruction to produce a *remou* of half a foot. How much will the original velocity be increased? The uncontracted water-way will be 1,000 × 10 = 10,000 square feet. The obstruction caused by the piers up to the water-line will be 8×12½×10 = 1,000 square feet. The sum of the distances between the piers will be 1,000 — (8 × 12½)=900 lineal feet. Multiplying this distance by the hight of *remou* gives 900 × ½ = 450 square feet. Hence we have for total obstruction 1,000 + 450 = 1,450 square feet, giving for the value of the contracted water-way, 10,000 — 1,450 = 8,550 square feet. Applying the rule given in the first article for determining the increase of velocity, we find that the said increase of velocity=(10,000 ÷ 8,550)—1=(1,450 ÷ 8,550) = 17 per cent. If we had paid no attention to the effect of the *remou* in diminishing the water-way, the result would have been the same as in the first illustration of the preceding number, namely, 1-9th or 11 per cent.

The question that would naturally claim our attention next in order would be the determination of the value of *b*, the hight of the *remou*; but I postpone the discussion of that subject, in order to introduce a second correction, in the method of determining the value of the contracted water-way. This is the last correction to be introduced.

When the channel of any water-way is obstructed, the particles of water, struggling to rush through the contracted portion, interfere somewhat with each other, so that they do not completely fill the diminished water-way, but contract themselves into yet narrower compass. Theory affords no method of calculating the amount of contraction thus produced. It gives us *theoretical* velocities, &c., of effluent water, made upon the supposition that no such contractions or losses of any sort occur, and then advises us to multiply these theoretical results by some corrective co-efficient, to give, practical results. The values of these co-efficients can be determined only by experiment. The values of the co-efficients of contraction cover a very wide range, depending upon the ratio of the sides of the opening to the area of the opening; the shape of the opening, the velocity of the water, &c. In the present case, we can reduce the range of values of this co-efficient, to quite a narrow compass. The bottom of the river bed, not being interfered with, there is no contraction there. Whatever depression takes place at the surface is included in the value of *b*, the hight of the *remou*. The only contraction, then, we have to examine, is that which takes place at the sides of the piers. No bridge would be erected over a river that was navigated at a time when the velocity of the current exceeded seven or eight miles an hour. No bridge over a navigable river, with a current at all rapid, would have the piers less than 150 feet apart. If the line of direction of the piers was parallel to the line of direction of the current (as it always should be), the loss of water-way, due to the "contraction of the fluid vein", would probably lie between the limits of half of one per cent and two per cent of the value of the contracted water-way as already determined. The half of one per cent would correspond to the case where the starling was so shaped as to shed the water most freely. The two per cent would correspond to the case where the upper end of the pier was nearly or quite at right angles to the current. Probably one per cent might be taken as a fair value for cases as they ordinarily present themselves. Hence to determine more accurately the value of the contracted water-way, we must deduct one per cent from the value found according to the preceding directions. To illustrate:—What would be the corrected increase of original velocity in the preceding example, making all allowance for "contraction of the fluid vein?" The value of the contracted water-way there given is 8,550 square feet. Deducting one per cent for contraction, we have for the correct and final value of the contracted water-way 8,465 square feet. Applying the rule given in the first article for determining the increase of velocity, we find that the said increase of velocity =(10,000 ÷ 8,465)—1 = (1,535 ÷ 8,465)=18 per cent. Hence in the present instance the increase of velocity, after making allowance for all circumstances influencing the case, will be 18 per cent of the original velocity. It will be observed that the corrections I have introduced do not affect the rule given in the first article. That rule is correct and general; the corrections merely affected the value of the contracted water-way to be used in connection with the rule.

When arches of short spans are thrown across rivers that are not navigable, and it is desired to obtain the velocity between the piers, in order to determine the amplitude of the back-water, &c., then a much greater allowance than two per cent must be made for the contraction. A greater allowance than two per cent must also be made, where the line of direction of the piers makes an angle with the line of direction of the current.

I conclude the present article by summing up the process for determining the corrected value of the contracted water-way:—*From the uncontracted water-way, deduct the aggregate cross sections of the submerged portions of the piers and abutments; from the remainder deduct the product of the sums of the distances between the piers, multiplied by the hight of the remou;* 99 *per cent of the second remainder will give the corrected value of the contracted water-way.* This value, used in the italicised rule of the first article, will give as correct a value to the relative increase of velocity, caused by the obstruction of the piers, as can be obtained by any process, however complicated. The simplicity of the operation renders it easy to detect any errors, which might escape notice in long and complicated operations.

My next communication will be devoted to the discussion of the value of *b*, the hight of *remou*.

[To be continued.]

WATER—ITS WEIGHT AND POWER.

In the operations of nature and art, no substance is invested with more interest than water. Without water, no plant, insect, fish, bird, beast or man could exist on our globe. It enters into the composition of every organism, and it also operates as a mechanical agent to drive the sawmill and cotton factory by the action of its gravity; or, in the form of steam, it propels the car and steamship by its expansive force being combined with heat. In commerce, water is the standard of the specific gravity of fluids; when, therefore, we see the specific gravity of alcohol set down at 0.794, and eupione oil at 0.655, it means that water is as 1.000 to each of these in weight; they are much lighter, and from this we learn that it is not owing to the lightness of one fluid as compared with another, that one floats on top and another mixes with water, because alcohol mixes freely with water, but most oils do not. Fluids mix together according to their peculiar natures, not their specific gravities. A cubic foot of water weighs 1,000 ounces, or 62½ lbs. An imperial liquid gallon contains 277.274 cubic inches (the United States liquid or wine gallon contains 231 cubic inches); therefore, a pound of water contains 27.72 cubic inches, and a gallon weighs 10 lbs.; while a cubic foot contains 6¼ gallons. A pipe one inch in diameter and one yard in length contains 28.26 cubic inches of water, which is a little over a pound, but near enough to call a yard of water in a one-inch pipe a pound. A very handy rule in calculating the contents of a water pipe is simply to square the interior diameter in inches, and the answer is in pounds for every yard. Thus: how many pounds of water are there in a pipe four inches in diameter and 30 feet high? Answer: $(30 \div 3) \times 4^2 = 160$ lbs.=16 gallons. These simple rules are valuable to all who convey water in round pipes from springs and other sources; also, for those who convey water in cylindrical draft boxes to water wheels. Water, at one time, was held to be incompressible; and, indeed, for all common purposes it may be so reckoned; but when deprived of its air, it is reduced in bulk 1-890ths by a pressure of 360 lbs.=24 atmospheres—on the square inch. It is this quality of resistance to pressure in water which causes it to be so useful as a means for transmitting power by a hydrostatic press.

Water, in falling, is subject to the same laws of gravitation as other heavy bodies; but as its particles have not the cohesion of solid bodies, it is understood that in speaking of the power of falling water, a continuous stream is meant. We presented a method of calculating the quantity of water flowing through an orifice under a high head on page 128, in which there was an error; the product of feet in velocity being multiplied into the square inches of orifice (which was right), but this was divided by 1,728 inches to obtain the cubic feet, which should not have been done; hence, but a fraction of the amount was obtained. The following is the correct method fully detailed to calculate the quantity flowing out under a 30-foot head from an orifice of 2 feet by 6 inches: $\sqrt{30 \times 5.1} = 27.897$ feet per second, which is 1,673.82 per minute, which amounts to 71.3 horse-power, by using 44,000 as a divisor. A correspondent in Lowell, who will soon furnish us with information on pressure and water-power, gives us the following formula, which brings out nearly the same results: $\sqrt{(64 \times 30)} = 43.8 \times .62 \times 1 = 27.156$ cubic feet per second. He uses the co-efficient of correction, .62.

THE NEW YORK CENTRAL PARK.

This is a great work, and the city will ultimately have to pay a *great bill* for it. The original cost for the ground was nearly $5,000,000, and in addition to this the city has paid $275,000 for State property within its limits; and now it is proposed to extend its dimensions on the north at the cost of another million, making a total of $6,275,000. The plan adopted for the improvement of this land called for an expenditure of $1,188,418—to which the Commissioners added "for contingencies," the liberal sum of $311,582—making a total of $1,500,000, which was to complete the park.

A bill is now before the Legislature from the Park Commissioners, asking for $2,500,000 more to complete the work, and $2,500,000 as an appropriation for keeping it in repairs. The Assembly, by a resolution, has called upon the Commissiones to report the amount already expended by them, and also the estimates to show for what purposes the additional $5,000,000 are wanted. An answer to this resolution has been given, in which it is stated that instead of a million and a half, the expenditures have already reached $1,813,004—over three hundred thousand dollars more than was first estimated to be necessary; that in addition for work already marked out, and which is specified, they will need $2,500,000, Then they want a principal ($2,500,000), the interest of which shall not exceed $150,000 per annum, with which to keep the park in order. Here is a total of $12,775,000. Some persons who can judge pretty correctly of such matters assert that the designs of the Commissioners, if carried fully out, will cost $5,000,000 more, making a total of $18,000,000. The Central Park threatens to become a perfect political whirlpool for sucking in the money.

THE "SCATTERING" OF SHOT GUNS.

MESSRS. EDITORS:—I am a gunsmith, and in our business we experience a great deal of trouble in preventing shot guns from "scattering." Although engaged in the business, I have never known any gunsmith who had a rule for constructing fowling-pieces so as to effect this object with precision and uniformity. Do you know of any rule to effect this? J. F.

[If a shot gun is bored truly—a perfect cylinder of equal diameter from muzzle to breech—and if the shot is of equal size and carefully loaded, the gun will carry very straight. We have heard of shot guns being made with a slightly enlarged breech chamber, for the purpose of slightly *drawing* the shot, when discharged, towards the center; but we do not think that any positive useful result was thus obtained.—EDS.