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

BY J. W. SPRAGUE.

About a year ago, I was called on to survey a portion of one of the largest navigable rivers in the United States, in the immediate vicinity of a bridge, which had been erected over it. The object of this survey was to determine how much the navigation of the river had been obstructed by the piers of the bridge; and to procure data for testing the accuracy of the calculations of those engineers who had preceded me. A suit, of the nature of an injunction, was pending against the bridge. The affidavits, already taken in the case, were submitted to me, when I was surprised to find the singular errors into which some of the engineers (whose high professional position entitled their opinions to command the respect of all) had been led, by seeking to apply the formulæ of the books to a case to which they were totally inapplicable. All must admire the accurate precision with which a mathematical formula points out the steps that are to be pursued to arrive at the desired result; but experience has satisfied me that it is rarely safe to trust a formula to the hands of any one who, either from want of time or lack of ability, cannot first *retrace* the steps by means of which that formula has been drawn from well-known data. So rarely do bodies in the physical world present themselves to our notice under *precisely* the same circumstances as those assumed in the data from which the formula is deduced, that it is almost always necessary to make some allowance for the change in the condition of things. He who attempts to make such corrections, without a thorough understanding of the formula he is using, gropes in the dark, equally inclined to wander further from the right path or to stumble back into it.

In the case alluded to, the formulæ of the books were based upon the supposition that the line of the piers was parallel to the line of the current of the river. A survey of the premises indicated a considerable angle between the line of the piers and the line of the current. The formulæ of the books were used, but whatever corrections were applied carried the result further from the truth than would the simple formulæ. Even where the case that presents itself to us corresponds exactly with the one from which the formulæ are derived, there is liability to error, from not *entering* the formulæ with the correct units of time, space, or weight. Some formulæ require all distances to be expressed in inches, others in feet. After a formula has been developed, upon the supposition that an inch is the linear unit, we cannot always afterwards change that unit to a foot, without a complete revision of the formula.

The preceding remarks will, I trust, be deemed a sufficient apology for introducing to the readers of the SCIENTIFIC AMERICAN, a series of articles on "The Obstruction to the Navigation of Rivers caused by the Piers of Bridges," in which a simple method will be pointed out, by means of which the increase in the velocity of the current, and the hight of *remou* or back-water produced, can be determined with a considerable degree of accuracy by any engineer understanding the first principles of his profession. Perfect accuracy, however, is unattainable by any process. It is also proposed to discuss the additional power required to carry a steamboat up through the draw of a bridge over that required for plain steaming. Not to perplex the student with too many refinements of processes at the outset, some statements will be made as if they were strictly correct; and afterwards modifications will be pointed out. Unless expressly stated to the contrary, it will be understood that the line of the piers is parallel with the line of the current.

Suppose, at a certain stage of water, the cross section of the water prism of a river, just above the pier, to be 10,000 square feet, and the sum of the greatest cross sections of the immersed portions of the piers and abutments to be 1,000 square feet; how much greater velocity will the water have between the piers than above them? The contracted water-way will be 9,000 square feet; and as the same amount of water must pass each second through the 9,000 square feet as though the 10,000 square feet of uncontracted water-way, it is evident that the velocities at the two points must be to each other inversely as the areas, or that the increased velocity is to the original velocity, as 10,000 is to 9,000, or as 10 to 9. This would give the *increased* velocity 10-9ths of the original velocity, and the *increase* of velocity 1-9th of the original velocity. As a rule, then:—*Divide the uncontracted water-way by the contracted water-way; the quotient, less unity, will give the relative increase of the original velocity caused by the piers.*

To test the accuracy of the above rule, take any velocity, say 18 feet per second, as the original velocity. The *increase* of velocity would be 1-9th of 18 feet or 2 feet, and the *increased* velocity 20 feet per second. The number of *cubic* feet of water, discharged through any area per second, is evidently equal to the product of the *square* feet of the area opening, multiplied by the velocity in *lineal* feet per second, with which the water flows through the opening. The quantity of water discharged per second through the contracted water-way will be 9,000 square feet × 20 lineal feet = 180,000 cubic feet. The quantity of water discharged per second through the unconstructed water-way will be 10,000 square feet × 18 lineal feet = 180,000 cubic feet. The products being the same in both cases, as evidently they ought to be, proves the accuracy, both of the rule, and of the operation performed under the rule. In practice, it is always advisable for the engineer to apply such tests, since there he will seldom find ratios so simple as those here chosen.

The rule given above seems to derive itself from almost self-evident propositions, yet in the case already alluded to, almost every engineer was led into error on this point, probably by such reasoning as this:—If the uncontracted water-way is 10,000 square feet, and the obstruction is 1,000 square feet, then the obstruction is 10 per cent of the whole water-way, and requires an increase of 10 per cent, or 1-10th of the original velocity, to carry the water through the piers. This fallacy, stated in the form of a rule would read:—Any per-centage of obstruction to the water-way causes the same per-centage of increase of velocity. To show the absurdity of this, take a case where 50 per cent, or half of the water-way is obstructed. The rule would give an increase of 50 per cent to the original velocity; but it is evident, that if we would force the same quantity of water per second through half of any space, we must give the water *twice* the velocity that would be required, if the whole space was free. Doubling the velocity is giving it an increase of 100 per cent, not of 50 per cent, as shown by the rule. Yet again: suppose the whole water-way, or 100 per cent, obstructed; then, according to the rule, the velocity would be increased 100 per cent, or doubled; and we should have the peculiar phenomenon of a river discharging itself through no space at all, by merely doubling its velocity. The correct rule, already stated, would give for such a case an *infinite* velocity, indicating an absurdity in the proposition. The reason why these absurdities did not discover themselves to the parties in question was, that the per-centage of obstruction being only about 1-10th of the whole water-way, the error would not show itself without some calculation.

I will close the first article of this series, by giving the test applied to the calculations of one of the most distinguished engineers in the country. I speak of him as such, in order to show, conclusively, how liable *all* are to fall into error. The data are those given by him; I have only combined them in such a way as to produce what may be called a *reductio ad absurdum*:—

Uncontracted water-way..................19,383 sq. ft.
Obstruction caused by piers, &c. (about 8½ per cent.)........................... 1,667 "

Contracted water-way......................17,716 "

Velocity in uncontracted water-way.....6.74 per sec.
Velocity in contracted water-way........7⅓ "

Water discharged per second through uncontracted water-way, 19,383×6.74=130,641 cu.ft.
Water discharged per second through contracted water-way, 17,716×7⅓=129,858 "

Error of calculation, as shown by quantity of water accumulating each second above the bridge......... 783 cu. ft.

Adding 8½ per cent to 6.74 gives 7⅓, showing conclusively how the result was arrived at, and how the error crept in. The real error was, however, much greater than that indicated above, as will be evident further on, when certain necessary modifications are introduced.

[To be continued.]

ALL the rivets of the British iron ships are to be covered with cement, to prevent the action of bilge water.

THE LIME LIGHT.

Some recent improvements in the calcium light have been made in England, which are attracting a great deal of attention. The London *Journal of Gas Lighting* contains a long article on the subject, from which we make the following extracts:—

A light of great brilliancy was, some years ago, produced by combining a large volume of oxygen gas with a congeries of argand or other burners, supplied with oil, and known as the "Bude Light," but, like others, it was finally rejected, as disadvantageous in practice. For many years—even as far back as 1820—attempts were made to obtain a safe and intense light by the ignition or combustion of a ball of lime, in the united flames of hydrogen and oxygen gases. It was employed for microscopic purposes, and is stated to be equal to about 264 flames of an ordinary argand lamp (consuming the best spermaceti oil), each of which is equivalent to ten wax candles of four to the pound.

About the year 1826, Lieutenant Drummond, who was appointed to conduct the ordnance survey in Ireland and Scotland, first applied the lime light in the focus of a paraboloid, on lofty eminences, where the stations were usually placed, as it was of great importance in those operations to have certain and determinate signals, which could, almost under any circumstances of the weather, be seen at great distances; and by it he successfully connected the opposite shores of Ireland and England at or about Holyhead—a distance of about 64 *miles*. He used, on some of those occasions, oxygen gas, and alcoholic vapor, but ultimately substituted hydrogen gas for the latter. In Scotland he obtained a most successful result on the summits of Ben Lomond and Knock Layd—a distance of 95 *miles*, thus demonstrating the practicability of adopting the lime light for long distances.

It was found by Drummond that many substances were capable of producing light in conjunction with gases, but that, of all those which were available for the perfect combustion of the gases, chalk lime was the most suitable material for the purpose, and hence the name of "Lime Light." It was also the cheapest and most easily attainable in any locality. It was likewise found that several gases, compounds of hydrogen, might be successfully employed in combination with oxygen gas, as well as pure hydrogen. Pure hydrogen gas, obtained from zinc and diluted sulphuric acid, offers facilities in cases where carbureted hydrogen, as supplied by the gas-works, cannot be readily procured; but coal-gas, where available, is a most desirable substitute for the ordinary applications of the light.

The generation of oxygen gas, which plays so important a part in the production of this light, is one of extreme simplicity. It is obtained cheaply and easily from a variety of substances, each existing in great abundance, viz., peroxyd of manganese (black oxyd), chlorate of potassa, nitrate of potassa (familiarly known as saltpeter), and some other substances, the employment of which for this purpose is, however, precluded by their cost, as oxyd of lead and red oxyd of mercury; but it is probable that these will yield a residuum as the other substances, which residuum will become an article of ready and remunerative sale, by which the cost of the gas produced from them will be reduced to a mere nominal value.

The peroxyd of manganese requires simply to be placed in a retort raised to a red heat, when the oxygen gas is freely disengaged. So soon as the gas ceases to be evolved from the manganese (which can only be effected practically to the extent of about 11 per cent, although it contains at times 80 per cent), the residuum, the deutoxyd or sesquioxyd of manganese, may be drawn from the retort; and if thrown into water, or exposed at a high temperature to the action of the atmosphere, it will attract oxygen with great avidity, and thus this refuse becomes revivified, or resumes its former state of a peroxyd, fitting it by this operation for a repetition of the distillatory process. This peculiar property of the deutoxyd of manganese (of rapidly absorbing oxygen from the surrounding air or other oxygenated bodies brought into contact with it) gives to this substance a great commercial value as a material for producing oxygen gas; for since the actual consumption of the manganese is thus limited by the quantity necessary to provide for the supply of gas during the time required for the revivification of the exhausted material, a comparatively small stock only will be needed to compensate for the unavoidable waste consequent on this mode of operating upon it. In addition to this source of economy, the demand for the deutoxyd of manganese for chemical purposes in glass-making, bleaching, and other processes in the arts, presents a means by which the residuum may be disposed of at a price which will leave the cost of the gas merely nominal. Thousands of tuns are imported annually into this country, from the continent, for the before-named purposes, and hence the disposal of the residuum is a matter of certainty.

The chlorate of potassa is a substance which, though costly at first hand, is nevertheless a valuable material for the production of oxygen gas, from the facility which it affords to the operator. The comparatively low temperature needed for its disengagement and the rapidity with which it is produced require less attention and labor. Hence the cost of the gas is not so great as would at first sight appear, when contrasted with that from manganese. The residuum is chloride of potassium, or familiarly, muriate of potash, and is used in the arts.

The cost of the lime will, under proper arrangements, be extremely small; the cost per hour for each jet may be taken at ·03 of a penny.

Having thus shown the modes of obtaining the elements of the light, it now only remains to describe the improved form of the instrument in which they are utilized, with some of the many important applications which are contemplated by the Lime Light Company. A patent was taken out in this country, in 1858, for "Improvements in apparatus employed in the production of light," by Mr. J. H. Bastable (a communication); and subsequently a patent for additional improvements was obtained (in 1859) by Mr. Prosser. The object of these patents is to remedy the defects of the former applications of the lime light. It has been invariably found that, although for short periods, for microscopes, and similar comparatively minor applications of the light, the adopted methods of applying the lime were, with great care, sufficient for the purpose, yet for the general purpose of lighting, the means were totally inadequate to the object; as the lime, when exposed to the action of the heat produced by the combustion of the gases or the influence of the atmosphere, unavoidably became cracked or decrepitated, and in this ruptured state, having no support, fell away from the jet of flame, and either rendered the light inconstant or entirely useless; for the ignited gases, without the presence of the lime, possess no illuminating power whatsoever, though they are in that state most powerful agents for the destructive separation of refractory substances.

To effect the desired object of protecting the lime from crumbling away and of insuring a practically unlimited supply, the simple expedient of enclosing the lime in a case or guard, both above and below the point of ignition, was resorted to, exposing only such a portion of its surface as was required for the action of the gases; and by giving to the lime so enclosed a movement within the tube, the retention of the ruptured portions of the lime was insured, until, by simple means, they were allowed to escape without detriment to the light, or were replaced by a fresh supply in as simple a manner as the cotton wick of an argand lamp, thus effecting, with the perfect continuity of the light for any reasonable period (a fortnight or more if necessary) of time, the maximum brilliancy of the light.

So simple are the mechanical appliances for producing these results, that they fall as much within the compass of the ordinary attention bestowed on such objects as that required for an ordinary lamp.

The extreme purity of the light eminently adapts it for interior illumination, as there is no evolution of deleterious gases or fumes (which from gas, are so destructive to works of art, as pictures, furniture and costly embellishments); nor any abstraction of the oxygen from the atmosphere, the requisite quantity for combustion being supplied by the instrument itself.

The light can be used either as a naked light, or in combination with the catoptric, dioptric, or the catadioptric systems, for lighthouses and ships of every class; for railroad stations and signals, both fixed and movable; for floating-light vessels or buoys in navigable channels; for bridges, wharfs, public buildings, factories, squares, and large and important thoroughfares; and by a judicious and compact arrangement of apparatus, its introduction into the interior of mansions where gas has not hitherto found access will doubtless be insured. The application to street lighting, from its extensive and important character, has been reserved for the serious consideration of the company, who have, however, so far matured their plans as to justify their anticipations of complete success.

BORACIC ACID IN THE PACIFIC.

In San Francisco there is an Academy of Natural Sciences, which has some very able and prominent members. At one of its recent meetings, a paper was read on the above subject by Dr. John A. Veatch, in which he stated that the fact of boracic acid being in the sea water along their coast was brought to his attention in 1857. Prior to that period he had discovered the borate of soda in the water of a mineral spring at the upper end of the Sacramento Valley, and he had found borates in nearly all the mineral springs of California. Borate of soda was so abundant in one particular locality that enormous crystals of that salt were formed at the bottom of a shallow lake, or rather marsh, one or two hundred acres in extent. The crystals were hexehedral with beveled or replaced edges, and truncated angles; attaining the size, in some cases, of four inches in length by two in diameter, forming splendid and attractive specimens. In the same neighborhood, a cluster of small thermal springs were observed holding free boracic acid in solution. A few hundred yards from these a great number of hot-springs of a temperature of 212° F., rose up through the fissures of a silicious rock. These springs held a considerable quantity of borax, as well as free boracic acid. Many other localities furnished similar indications, but in a less extensive form.

"In progress of examination," says Dr. Veatch, "I found that the common salt (chloride of sodium) exposed for sale at the San Francisco market; and which, it was understood, came from certain deposits of that article on the sea margin in the southern part of the State, also furnished boracic acid. I was led to attribute it to the fact of mineral springs emptying into the lagoons furnishing the salt. It was, therefore, a matter of no small surprise, when on a visit to the localities, I found no trace of acid in any of the springs in the adjacent district. This led to an examination of the sea water, and a detection of an appreciable quantity of boracic acid therein. It was at Santa Barbara where I first detected it, and subsequently at various points, from San Diego to the Straits of Fuca. It seems to be in the form of borate of soda, and perphaps of lime. The quantity diminishes toward the North. It is barely perceptible in specimens of water brought from beyond Oregon, and seems to reach its maximum near San Diego. This peculiarity seems to extend no great distance seaward. Water taken thirty or forty miles west from San Francisco gave no trace of acid. In twelve specimens taken at various points between this port and the Sandwich Islands, furnished me by Mr. Gulich, of Honolulu, only that noarest our coast gave boracic acid. In ten specimens furnished me by Dr. W. O. Ayres, taken up by Dr. J. D. B. Stillman, in a trip of one of the Pacific mail steamers from Panama to this place, no acid was observed south of the Cortez Shoals."

AMERICAN MACHINERY FOR THE AMOOR RIVER.

We saw, last Monday, at pier No. 11 North river, in this city, one of J. C. Hoadley's portable steam engines on its way to Mantchooria. Mr. Hoadley received a letter from the Novelty Works in this city, on Saturday, Feb. 18th, ordering the engine on condition that it could be in this city on Tuesday, March 6th. As it would require to be finished on Thursday, March 1st, at his shop in Lawrence, Mass., this gave Mr. H. less than two weeks to do the work. He however accepted the order at once, and immediately took his horse and visited his workmen, to have them on hand early on Monday morning; and as a carriage for this particular engine required some peculiarly heavy seasoned plank, he telegraphed in various directions to learn where this might be procured. The man who made the axles was induced to run his shop on the holiday of Feb. 22d, and by this energy the engine was landed in this city one day before the specified time, all finished in the most thorough and substantial manner, with everything necessary to its operation in the wilderness to which it is to be transported, more than 15,000 miles away.

We understand that this engine is intended to drive one of Parkhurst's saw mills, and is to fill part of a large order for machinery which the Novelty Works had received from a Russian now in this city, who intends to take it to the Amoor, in the north east corner of Asia, where he expects to sell it to the Russian government.

It is the same style of engine as the one mentioned by us in the notices of the fair of the American Institute last Fall. Mr. Hoadley tells us that that notice, occupying perhaps two inches in one of our columns, brought him more than 50 letters. Considering that the prices of his engines range from $300 to $2,300 and that consequently these 50 letters relate to the purchase of some $50,000 worth of property, this affords a striking proof of the influence of our paper.

CURING SMOKY CHIMNEYS

MESSRS. EDITORS:—I wish to notice an answer which you gave to C. Q. L., of Mo., on page 110 of the present volume of the SCIENTIFIC AMERICAN, where you say "the higher the chimney, the better the draft." That theory will not always hold good in practice. In fact, I have noticed some chimneys that smoked worse, if possible, by being built higher. My theory is: the higher the chimney—if properly built, and of the right size—the better the draft. As an illustration of the above, I will state a fact that occurred a few years ago, while I was engaged in chimney-building. A gentleman came to me, and said he had two chimneys (on the two wings of his house) that smoked very badly. They were 11 feet high above the roof; and on one of them he had tried a stove-pipe 10 feet long, with a cap on top to turn with the wind, yet it smoked worse than before. He now wished them "laid over," or fixed so as to prevent smoking, but would not have the job done unless warranted to cure. I undertook the job. The size of the chimneys was 20 by 32 inches on the inside. I took them down only to the roof, and commenced laying them up, drawing in gradually till the size was reduced to 4 by 12 inches on the inside; then carried them up straight to within 18 inches of the top; then laid out again, in laying on three courses of brick, to increase the size to 8 by 16 inches on the inside; then drew in on three courses, back to the size of 4 by 12 inches, and laid another course perpendicular to the last; the whole hight being only five feet above the roof. Neither of those chimneys has ever smoked since that time—a period of eleven years.

Munnsville, N. Y., Feb. 25, 1860. L. L. G.

[The question of "curing smoky chimneys," and the *draft* of chimneys are not the same exactly in a scientific point of view. A chimney may smoke—that is, may have a deficient draft, owing to the situation of the house on which it is placed; and by increasing its hight, the evil may only be aggravated, as our correspondent has justly observed. We have known several cases of this kind. The houses were situated where whirls of wind forced the smoke down the chimneys. The latter must be constructed according to circumstances, and the practical information which our correspondent has furnished is very valuable; still it is true as a principle that "the higher the chimney, the better the draft," and it is upon this theory that all the tall chimneys for factories are constructed.—EDS.

TENEMENT HOUSES—A GOOD IDEA.

MESSRS. EDITORS:—I beg leave to suggest a simple, sure, durable, cheap and easy fire-escape for tenement houses. Such houses are generally from 20 to 30 feet higher than the adjoining houses. Let an iron ladder be permanently annexed to the side wall of the tenement house, thus connecting the roof of the tenement house with the roof of the adjoining house. In case of fire, the inmates occupying rooms below the origin of the fire, may escape by decending the common stairs, those occupying rooms above the origin of the fire may escape by ascending the common stairs to the roof, and making use of the iron ladder to reach the roof of the adjoining house. Thus all will be saved. Such an iron ladder would cost from ten to twenty dollars, according to the length. No landlord would (at the request of one respectable tenant) refuse to furnish it. No tenant of a tenement house should neglect to demand it. But I trust that this communication will arrest the attention of some member of the legislature, who, appreciating the effectual and wholly unobjectionable character of this improvement, will procure the enactment of a law requiring its adoption for all tenement houses.

J. A. D.