Correspondence.

Chains vs. Cables in the Manhattan Bridge.

To the Editor of the Scientific American:

An editorial review of my letter of September 13, published in your issue of September 30, criticises my statements, that an eye-bar chain will weigh about 4.84 times as much as a wire cable of equal strength, and that, therefore, the Manhattan Bridge, if built on the former design, would cost from four to five millions more than if built on the latter plan.

Some doubts are expressed in this editorial, not only as to the correctness of the calculations on which my statements are based, but also about my personal ability for making such calculations. An attempt was made to justify these doubts by relating some historical facts, from which misleading inferences may be drawn, and by comparing certain figures which, being incompletely quoted, give wrong results.

I trust, therefore, that you will accept the following corrections and additional explanations:

In the first place, I beg to state that I do not claim that any kind of wire cable bridge is cheaper than all kinds of chain bridges, but my calculations refer only to a comparison between two bridges of the same length and capacity, and having the same coefficient of safety in all their parts. In this case, a comparison between the weight and cost of two kinds of cables, consisting of different material, is extremely simple, and can be made *accurately* by "rough and ready methods" without consulting the strain sheets of secondary parts of the bridge. Whoever claims that the latter is necessary and that such a comparison is a complicated problem, known only to few engineers, is either totally inexperienced in the construction of suspension bridges, or he is willfully mystifying a clear matter, in order to avoid a direct response to the simple calculations which he is unable to contradict!

It is claimed, in your review, that I failed to convince the board of eminent engineers about the correctness of my statements. There is no evidence for this assertion. The board never questioned the correctness of the calculations nor contradicted them, and never pointed out where they were wrong, if wrong at all. The fact is, the experts never discussed the question at issue, but they merely ignored it. This can be explained by the circumstance that the eminent engineers were not engaged and paid to discuss or dispute with me questions which did not concern them; they were not engaged for making comparisons between wire and chain cables; they were not asked to determine whether the eye-bar plan was cheap or expensive, nor whether any other design would be better and more economical. They were merely engaged for giving their opinion whether the design, submitted to them, was practical, whether the bridge, after being finished, would be fireproof, durable, and serviceable, and whether it would have sufficient capacity and strength. These questions were answered with "yes," and if I had been a member of the committee I would, with strict adherence to the same questions, have given the same verdict!

The action of the board of engineers is, therefore, no criterion for the correctness or incorrectness of my statements.

Your editorial mentions also the Buda-Pesth bridge, where the question of eye-bar chain or wire cable, considered "purely on its merits," was decided in favor of the former. I beg to say that you were wrongly informed. The fact is that, among many competitive designs, one of a wire cable bridge stiffened by trusses, submitted by the Nuernberg Bridge Works, was selected by a board of eminent bridge experts as the best and was awarded the first prize. The local authorities, however, fully acknowledging that a wire cable would be cheaper, decided in favor of the eye-bar chain for patriotic reasons, because eye-bars could be manufactured at home, while wire had to be imported from other countries. Moreover, wire would have been subject to a heavy import duty, while eye-bars were free from it, which helped considerably to reduce the greater cost of an eye-bar bridge. In spite of this circumstance, favorable to eye-bars, it is conceded that the chain bridge was 12 per cent dearer than the wire bridge would have been, notwithstanding the fact that the unit stress in the eye-bars is relatively about twice as high as it would have been in the wire cables. (These data are taken from the Zeitschrift des Vereins deutscher Ingenieure.)

The Buda-Pesth bridge is, therefore, no criterion for the relative merits of wire or eye-bar cables. Now I will show, by the figures quoted in your editorial, that the proportions of weight between wire and eye-bar cable is not 1:2, as stated therein, but that it was correctly given in my letter of September 13.

One of the wire cables of the Manhattan Bridge is quoted to contain 275 square inches, hence the average section of the cable, if it could be varied like a chain, would be 265 square inches. This, compared with the average section of 555 square inches for the eye-bar chain, gives the following relative strengths: Breaking strength of one chain: 555 × 40 tons = 22,200 tons; breaking strength of one wire cable: 265 × 112 = 29,680 tons. Forty tons is the ultimate strength per square inch of nickel-steel eye-bars, as accepted by the bridge department for the Blackwell's Island Bridge, and 112 tons is the tested actual strength per square inch of the wire in the Williamsburg Bridge.

The wire cables of the Manhattan Bridge are therefore at least 33 7-10 per cent stronger than the eye-bars in the chain bridge design. As my comparison of weight and cost is for cables of equal strength, the true useful section of one chain is therefore 555 + 33 7-10 per cent = 742 square inches, to which 20 per cent must be added for eyes and pins, making the actual section of one chain 890 square inches, which, compared with 275 square inches, is not twice, but 3.23 times as much as the section of the wire cable.

The total weight of steel in the bridge is, as correctly quoted, 41,700 tons. Subtracting from this weight the weight of anchor chains, towers, saddle castings and hand-rail ropes amounting to 15,800 tons, we obtain 25,900 tons for the weight of the steel superstructure, of which 12,400 tons are in the main span. Adding to the latter figure 1,760 tons (= 2,400 pounds per lineal foot) for floor measurements and 5,880 tons (= 4 tons per lineal foot) for live load we find the total dead and live load of the main spans to be 20,040 tons, of which the wire cables weigh 3,180 tons and the other parts, including live load, 16,860 tons. To support the same weight of 16,860 tons with eye-bar chains, the total weight of the main span would be 16,860 + (3.23 × 3,180) = 27,130 tons, which is 35 per cent greater than the present weight. For supporting this increased weight, the former chain section of 890 square inches must be increased in the proportion of 27,130 : 20,040, making it 1,205 square inches, which is 4.38 times as much as the wire cable section.

The discrepancy between this figure and 4.84, as given in my letter of September 13, is due to a difference in the assumption of the relative strength of nickel steel and wire. In the present calculation I compared the strength of nickel steel with the wires in the Williamsburg Bridge, which is as 1 : 2.8, while in my former calculation I assumed the more correct proportion of 1 : 3, because there is no trouble in manufacturing wire having an ultimate strength of 120 tons per square inch. Giving the benefit of the different assumptions to the eye-bar chain, its cost will still be $3,268,500 more than that of wire cables.

The above given figures are mathematically correct and not based on guesswork, as intimated in your editorial, and it is, therefore, not fair to doubt the figures or make light of them, unless someone clearly shows where they are wrong, if wrong at all.

I took the same standpoint before the board of engineers but, so far, nobody has ever tried to contradict or disprove my calculations. The only attempt to do so, in your editorial, has, as I have demonstrated, failed because in the given weight of the eye-bar chain, the weight of eyes and pins was omitted, and a comparison was made between two kinds of cables, of which one was 33 per cent stronger than the other.

That the anchorages for the wire cable plan are more costly than for the chain cable design, as stated in your editorial, is decidedly an error. The anchorages must resist the pull of the cables, which is in direct proportion to the weight of the bridge. It is therefore impossible that a heavier bridge should require less anchor masonry than a lighter bridge. We have seen that the dead weight of the eye-bar plan is 50 per cent greater than that of the wire bridge, and, including an emergency live load of 8 tons per linear foot, the former is still 27 per cent heavier and will, therefore, require 27 per cent more anchor masonry than the latter. In the same proportion the anchor chains, the section of the towers, and the area of the foundations must be increased in order to support the greater weight of the eye-bar bridge.

In my first paper on this subject (published in Engineering News of March 12, 1903), I have shown that the additional cost for such an increase in anchor chains, anchor masonry, towers, and foundations amounts at least to one million dollars, which, added to the excess of cost of eye-bar chains, demonstrates that a bridge on this design will cost at least $4,268,000 more than a wire cable bridge of equal size and strength.

It is possible that the chain cable design contains some economic features (for instance, hinged towers) which are not contained in the wire cable design; but all these features are independent from the nature of the cables, and could be adapted to either design. It was not my object to compare two designs in all their details, but to show what influence on the cost of the structure the application of eye-bar chains has, in place of wire cables. We have seen that the difference in cost is so enormous that, in comparing the two designs as they are, and with a liberal allowance for all economic advantages claimed for the eye-bar design, it is evident that the latter will cost fully or nearly $4,000,000 more than the present wire cable design, and not $2,000,000 less, as claimed in your editorial.

Wilhelm Hildenbrand.

New York, October 21, 1905.

[A discussion of this letter will be found in the editorial columns.—Ed.]

The Queen Bee and Poison.

To the Editor of the Scientific American:

The article entitled "Precautions Against Poisoning the Queen Bee" which I wrote for the Scientific American has called forth a reply from the editor of an agricultural paper, in which reply the accuracy of my statements is questioned. The article in question summarizes the results of many experiments conducted by myself.

I do not profess to be superior to mistake, but I certainly took much care and sacrificed eleven queens in making my observations, to ascertain how long they live on plain honey. In common with others, I long considered the evidence that queens were frequently seen lapping honey, as conclusive. I determined, however, to test the matter and conducted a series of experiments the deduction from which must "hold the field" until something superior is provided. Not one of the queens experimented with survived 12 hours on unsealed honeycomb kept at a temperature of 65 to 70 deg. F. The unmated queens made the record of nearly 12 hours; none of the laying queens survived two-thirds of that time, some expiring in less than 12 hours.

Now if a queen bee has been kept out of the reach of any attendant bee for twenty-four hours, alive on honey, my observations would be upset, but until some specific statement on these lines be made, I hold to the accuracy of my investigations on this point, and shall await with interest information as to the exact character of other experiments.

Inasmuch as everything stated in my note is impliedly challenged, I may add that the description of what goes on in the wasp's nest is another piece of independent observation. For years I have made a practice of securing several tree-wasp's nests, removing the outer covering and placing the comb in a glass case where the wasps could fly freely out-doors, and their movements could conveniently be watched.

J. M. Gillies,

Lecturer in Beekeeping, Albert Agricultural College (Government).

Drumcondra, Ireland, October 18, 1905.

Another Spontaneously Moving Stone Ball.

To the Editor of the Scientific American:

In a recent number of the Scientific American there was an illustrated description of a monument surmounted by a stone ball, which was apparently spontaneously turning on its support. It may interest your readers to know that an almost exactly similar phenomenon has been observed in the case of a granite cemetery monument in the Bradford district of this city. The monument, which has been erected about ten years, bears on the top of the shaft an immense granite ball nearly eighteen inches in diameter, resting in a cup-shaped depression. Since it was placed in position the ball has moved nearly a quarter of its circumference in a northeast and southwest vertical plane, and the unpolished portion of the ball which originally rested in the depression now faces the northeast horizon.

There seemed to be a great variety of opinions as to the cause of the movement of the ball described in your previous issue, but in the case of the Bradford monument I think the explanation is obvious. It will be noted that the movement of the top of the ball is toward the winter sun. The remains of a lead washer placed between the ball and the shaft, now very much corroded and broken, allow free access of water to the cup-shaped space between. Now let us assume, as would almost certainly be the case, that the depression becomes filled with rain or melted snow, and afterward freezes. As is well known, water in freezing expands with an enormous force quite sufficient to lift even the massive stone ball a small fraction of an inch. Imagine this to occur on a cold night. The next day as the sun moves round to the southwest, it warms the stone and melts the ice *on the southwest side first.* Naturally the ball will topple over slightly in that direction, and as the remainder of the ice melts will settle down in its new position. A repetition of the process of freezing and thawing will cause it to turn a little farther, and so in the course of years the movement becomes very evident. There are no trees or other obstructions to the sunlight in the vicinity, and it seems as if the all-powerful radiant energy of the sun must be the sole cause of this remarkable movement of a mass of stone weighing at least several hundred pounds.

Austin P. Nichols.

Haverhill, Mass., October 25, 1905.