One of the most decidedly novel and efficacious inventions for purposes of war that has made its appearance for some time is that of the new "fortress gun." It is one of those decisive steps in advance which occasionally appears as a result of persevering and long-continued experiment and study, and is, I think, destined to seriously modify present engineering methods of offence against fortified positions. It is the invention of Major-General the Baron Hahn, in 1872, at about which time the Russian Government had begun to give its attention to the necessity for some such weapon. An artillery commission, appointed by the Government, for the purpose of investigating the subject, first required of the engineer department a detailed statement of what was required to best prevent the approach of an enemy by parallel and other engineering device. With their statement the commission then referred the matter to General Hahn, with the view of obtaining the exercise of his well-known ability in the production of something to meet the requirements of the case. Early in 1872 the primary principles of this weapon were decided upon by the General, and soon after the first trial of it was had, with marked success; not, however, without the discovery of defects in the weapon, which General Hahn at once set about to overcome. In March, 1873, a second model was completed for trial; but it was not until near the end of the summer of 1875 that the weapon, as finally accepted by the Government, was completed, tried, and approved. At the last trial the artillery commission tested the gun without the presence of General Hahn, and, as a result of their report, it has been adopted by the Russian Government. The essentials decided upon by the commission for the weapon were, that it should be sufficiently accurate to insure the striking of a target of one foot square at 1500 to 2000 yards, and, at the same range, to penetrate the devices used in defence of men in "parallel" advances, rifle-pits, etc. For the penetration of "sap-rollers," gabions, etc., it would seem to be simply necessary to provide a weapon which could be handled with facility and capable of discharging a sufficiently heavy leaden projectile with accuracy to the required distance; but to pierce the heavy steel and iron plates used in similar siege operations was a more difficult problem, and this has been solved in a most ingenious and effective way. The projectile proper is a hardened steel cylinder, something less in diameter than the bore of the gun, with one end given that rounded form generally denominated conical when applied to a projectile. This cylinder is, to quote their own term, "circum-fused" with lead upon its whole length, except a small part of the point, with the usual ring-like projections for filling the rifle grooves of the gun. In the use of this projectile against metallic plates, the steel bolt passes through the plate, leaving the coating of lead behind, while the latter serves perfectly to fill the grooves of the rifle and insure that rotation which is required for accurate shooting. The weapon itself is simply a rifle, having the general form of an infantry arm, but of such calibre and weight as to preclude its use as such. It is intended to be used only in the embrasures or upon the parapets of fortifications, and is laid upon some comparatively solid rest, with a bag of sand supporting it at about the centre or just in front of the recoil-hook. The object of this hook and sand-bag is to receive the principal recoil, while in the butt of the stock is a spring, which, reacting against the movable shoulder-piece, relieves the shooter from what residual shock there may be. Resting in this way on the sand-bag, although quite heavy, the most accurate aim may be had with it, while, as it has a very simple and quickly-operated breech-loading arrangement, a most rapid and effective fire can be maintained from it. In loading, the breech-piece is thrown to the left, which ejects the empty metallic case; the new cartridge is then inserted, and the breech-piece thrown again to the right, when cocking and discharging complete the round. A man can do accurate shooting with it at a rapid rate; but as this is not important where the gun is used, no trials for rapidity have been had. The calibre first tried was $\frac{1}{2}$ in., but finally reduced to $\frac{3}{4}$ in., which is now the standard bore.

The grooves are eight in number, make one turn in 33.69 ins., are 0.015 in. deep and 0.21 in. wide. The outside diameter of bullet is $\frac{1}{2}$ in. The steel cylinder or "slug" weighs $3\frac{1}{2}$ oz., the charge of powder $\frac{1}{2}$ oz., and the entire cartridge $6\frac{1}{2}$ oz. The weight of the arm, including the recoil hook, is 45 lbs. avoird.; it can, therefore, be easily transported from place to place by one man.

The length of barrel is, including the cartridge-chamber, 37.75 in., and under trial the initial velocity of the bullet was found to be 1408.2 feet per second. The experiments had with the perfected gun were very satisfactory; in one case a $\frac{1}{2}$ -inch iron plate backed with $2\frac{1}{2}$ inches of hard wood was perforated at 2000 yards.

At 1500 yards, bags of sand 2 feet in circumference and 2 feet long were placed side by side and penetrated through the whole. Among the later trials for accuracy at a target of 1 foot square: at 600 yards, of 40 shots 7 entered the target; and at 1500 yards, of 80 shots 5 were within the 1 square foot; in fact, such were the results of the entire set of experiments that the Artillery Committee reported that for the purpose designed the gun was perfect, both as to its performance and the facility with which it could be manipulated; and their approval was equally decided as to the simplicity of design and its ability to withstand wear and tear; in their own words, they consider the gun "good and simple in all parts and mechanically perfect."

The cartridge-case is of sheet brass, and is made from a flat piece by means of a longitudinal seam folded after the manner of our ord nary tinner's seam, stamped together; the closed end of the case is in form of a cap stamped up from the sheet and pressed on with a single seam similar to the longitudinal one; this cap is perforated with several holes within a circle of about $\frac{1}{2}$ inch diameter at the centre, for the entrance of the fire. The holes occupy the base of a conical "anvil," formed in the cap, upon which the percussion-pin reacts to explode the percussion-cap which covers the perforations above mentioned.

I will endeavor to give you in future letters, descriptions of the other most prominent articles in this interesting exhibit. J. T. H.

THE NORWALK PUMP.

OUR illustration represents a steam-pump exhibited at work in the pump annex in Machinery Hall, at the Centennial Exhibition, by the Norwalk Iron Works Company, of South Norwalk, Ct. An excellent feature of this pump is the facility with which the parts can be removed when necessary for repairs. The valve-chest is removable from the steam-cylinder. The inside steam-cylinder, inside water cylinder cover, and the frame-piece between the two are cast in one piece. The piston-rod is of solid cold-drawn composition, and is fitted to the piston-heads by a taper and two check-nuts. The pumping-barrel is a composition tube bear-

ing loosely upon its ends upon collars turned in the main casting, which serves as guides to hold it central, and is held securely in position by the piston-rod stuffing-box screwing into one end, and drawing the tube or bushing against a shoulder at the other end, thus making it perfectly tight and solid. This forms the pumping-cylinder, and all the wear takes place in this bushing. When it becomes excessively worn, it is but a few minutes' work to unscrew the stuffing-box, which is of composition, and can not therefore rust in the thread, to take out the bushing and replace it with another. The old bushing can, however, be restored and replaced if there is time to perform the operation. The collars in the pump and on the bushing are accurately fitted to gauges. No pipe connections need to be disturbed, and hence no delay is experienced.

The pipe connections are made by flanges and stud-bolts, so as to facilitate their removal in case of necessity, by avoiding the annoyance due to corroded screw-threads. The water-valves are placed above the pump-barrel, which is the most favorable position for giving to the pump a free supply of water; they are circular valves, four in number, and are pressed to their seats by spiral springs. The valve-seats are of gun-metal and are turned taper, and driven into the pump, so that they can be readily removed when necessary. The water-valve chest and water-passages being large, a large body of supply water is kept close to the pump-barrel, thus materially assisting the obtainance of a full supply of water to the pump-barrel, an object of great importance when we come to consider the great difference between the displacement of ordinary pumps and the quantity of water actually delivered, especially when running at high speeds. The pump here illustrated is a No. 11, the diameter of the steam-cylinder being 16 inches; diameter of water-cylinder, 10 inches; length of stroke, 16 inches; capacity per double stroke, 10.86 gallons; strokes per minute from 100 to 200; mean capacity per minute, 500 gallons; size of nozzle for fire purposes, $1\frac{1}{4}$ inch; vertical height of stream, 135 feet; horizontal distance of stream thrown, 209 feet; steam-pipe, 2 inches diameter; exhaust-pipe, $2\frac{1}{2}$ inch diameter; suction-pipe of pump, 8 inches diameter; discharge-pipe, 6 inches diameter.

From these figures we find that the water, when the pump is working at its mean speed, travels up the suction-pipe at a speed of about 175 feet per minute only, which is a great advantage, because the column of water is not liable to break in consequence of the friction due to drawing it through the

THE INTERNATIONAL EXHIBITION OF 1876.—THE NORWALK PUMP.

pipe at a high speed—the limit allowed by Mr. Bourne, in his catechism of the steam-engine, being 500 feet per minute, which is allowed to be the fastest speed at which water can be drawn through a pipe in a solid body. It is considered a good pump that will throw 80 per cent of the water due to the displacement of its water-piston; here then is a loss of 20 per cent, which can only be accounted for in the lift and fall of the suction-valves, and in the loss due to the retardation of the water in the suction-pipe, in consequence of its friction against the sides of the pipe. When the water-piston is at the end of its stroke, and its return movement takes place, the piston travels some little distance before the suction-valves close, and during this interval the column of water in the suction-pipe is given a backward motion by the water passing, until the suction-valves close back through those valves. For these reasons it is highly advantageous to make the suction-valves of larger diameter, so that not much lift will be required of them in order to obtain sufficient area for the water to pass through, for the larger the valve the less it requires to lift, and the sooner it closes after the water-piston has arrived at the end of its stroke. Then again we must consider that since the area of a circle increases as the square of its diameter, there is only one fourth as much friction of the water travelling through an 8-inch pipe as there would be if the same quantity travelled through a 4-inch pipe, because the area of contact between the water and the sides of the pipe is as compared to its volume as four is to one. This is supposing the water to travel in both cases at the same speed; but if we require, as in this instance, to draw a certain quantity of water through a pipe in a given time, we must remember that the water will require to pass through a 4-inch pipe at four times the speed that it would require to pass through an 8-inch one, thus again increasing the friction fourfold in the case of the smallest pipe, so that the friction will be only one sixteenth as much in the 8 inch as it would be in the 4-inch pipe. From these considerations the large area of the valves and suction-pipes of the Norwalk pump are excellent features. The workmanship upon these pumps is well fitted and finished, and they have a neat and mechanical appearance. J. R.

LAKE FREIGHTS have never been as low as they are at present, three and a half cents being the prevailing rate on grain from Chicago. On coal to Chicago from this port, the rates have dropped to 40c.; to Milwaukee, 35c.; and to Detroit 30c. Coal has been very scarce, but the termination of the Tuscarawas Valley troubles will bring an almost immediate improvement in this respect.—*Cleveland Review*.

THE GAUGING OF RIVERS.

By D. FARRAND HENRY, M. Soc. C. E., Chief Engineer Detroit Water-Works.

IN the year 1850, Congress made an appropriation for the survey of the delta of the Mississippi, and for an examination into the causes of the inundations of that river. In 1851 two parties were formed for the carrying out of this work—one in charge of Capt. A. A. Humphreys, Top. Eng., and the other under Mr. Charles Ellet, Jr., C.E. During the prosecution of the work, Captain Humphreys was taken sick, and the year following a report was made to Congress containing a brief account of his work by Colonel Long, and an extended essay on the causes of the inundations and best methods of preventing them, by Mr. Ellet. The latter used the double float in the determination of current velocities.

In 1857, Congress made a further appropriation for the continuation of the survey, and the work was carried on during 1858 and 1859 by Lieutenant H. L. Abbot, under the general supervision of Captain Humphreys, the methods introduced by Mr. Ellet being generally adopted. The use of the double float was especially continued, metres being reported unpractical and unreliable. In 1861, Captain Humphreys and Lieutenant Abbot made a report to Congress on the "Physics and Hydraulics of the Mississippi," giving an account of the inundations, their causes, and possible prevention, which was simply an elaboration of the previous report by Mr. Ellet, and also a statement of new theories and formulae for flowing water founded on their velocity observations.

The first error into which they were led by following Mr. Ellet's report was that contrary to the well-known habit of all other rivers, the bed of the Mississippi was stationary, or, as General Humphreys succinctly expresses it in a letter to the *Mobile Register*, dated June 17th, 1871: "The evidence as to that matter is conclusive, that it has not risen, is not rising, and will not rise." This led them to endorse the levee system, or the raising of the present sinuous banks, and lessening the discharge by means of side channels, an ancient and therefore respectable method, but which has done more to devastate the plantations on the lower river than any other cause. The falsity of this system has been thoroughly demonstrated by many able writers, especially by Mr. Albert Stein, of Mobile, and recently by Captain James B. Eads. Another theory advanced by them, and which was apparently proved by the errors of their current measurements, was the excessive bottom velocity of the river, from which naturally

followed the idea that the bars at the mouth of the Mississippi were formed by the material being pushed along the bottom, instead of being held in suspension by the velocity of the current, and dropped when that velocity is lessened by the waters of the river being spread out over the surface of the Gulf. The adoption of this theory also shows the conservatism of the Corps of Engineers, who rejected the jetty system proposed by Mr. Albert Stein in 1835, and in 1838 commenced the dredging and scratching of the bar, because, as Mr. Stein says, "It had been stated by one, unfortunately higher in office than in the science of hydraulic engineering, that dredging has the advantage over all other plans that if it does no good it will do no harm." And so for nearly forty years, at a great expense to the Government, this harmless but useless attempt to abrogate one of nature's laws has been going on; but now, in opposition to the recommendation of the Corps, the jetty system has been adopted, and Captain Eads is proving the falsity of the theory on a grand scale. But the thing upon which the authors of the above-mentioned work most prided themselves was the discovery of the parabolic form of the velocity curve, and the elaborate new formulae of flowing water founded thereon. J. J. Révy, in *Hydraulics of Great Rivers* (page 8), says in regard to these observations: "We have already devoted more space to consider the movement of single and double floats than they deserve at the hands of engineers, and we have done so because one of the latest of any river surveys of modern times—the great Mississippi survey—had been conducted by single and double float observations upon a grand scale as a means to determine the currents of the river. The engineers of that survey relied entirely on floats; and we consider it a misfortune to science and to practical engineering that so much ability, perseverance, and time should have been spent to obtain results which the unfortunate choice of floats has inconveniently marred and confused."

In 1867, General W. F. Reynolds, then Superintendent of the Lake Survey, was ordered to make observations on the outflow of the lakes, and the writer was placed in charge of the work. The first season the double float was used in the determination of the velocities, but with such discordant results that a more careful examination of the Mississippi observations was made to see how the velocity curves then given were obtained. The results of this examination have already been published (*Journal Franklin Institute*, Vol. LXII., and *Flow of Water in Rivers and Canals*, p. 68), but they may be briefly stated as follows: The length of time spent in making the observations shows that at least 10,000 floats were passed at all depths, but on pages 230 and 246 of

the report (*Physics and Hydraulics of the Mississippi*), the record of only 2275 of them are given on 69 verticals.

Of these selected observations, Dr. Hagen says (*Bewegung des Wassers in Strömen*, p. 6):

"Extraordinary anomalies are shown when these series are graphically represented. In some of them the curves are quite regular, but in others the velocity remains nearly the same from the surface to the bottom; but frequently, with increasing depth, it increases and decreases considerably. Generally the velocity decreases with the depth, but a few series have an opposite tendency—that is, a surprising increase near the bottom of the river." Of the 69 selected verticals 24, over one third, show the maximum velocity at mid-depth or below; one of them giving it at one foot below the bottom. This is entirely different from all previous river observations, quite a complete list of which is given in the Report, pp. 204-6, the maximum having been found at or near the surface by all observers. There must, therefore, have been some strong reason for selecting observations which most observers would have rejected entirely.

On page 251 are given some current measurements made on a small canal near Washington, by Lieut. Abbot, in December, 1859. It was found that a reversed parabola with its axis (the maximum velocity), about two tenths the depth below the surface, would pass through most of the observed velocities. This canal was 23 feet wide and 7 feet deep; and according to MM. Darcy and Bazin's experiments on small canals, the locus of maximum velocity should be at a little over two tenths the depth, for a compilation of their observations shows that the maximum on the centre vertical remains at the surface until the depth is about one fourth the width. (*Flow of Water in Rivers and Canals*, p. 19.) In order to make the Mississippi observations agree with the above, the 69 verticals had to be selected and so grouped that the means would give the same result. Besides, this reversed parabola below mid depth is practically a straight line, and cuts the bottom at a very obtuse angle, giving an excessive bottom velocity, which as we have already seen, they assume to be the fact; although Captain Boileau, from whom they borrowed their parabola, says (*Measures des Eaux Courantes*, p. 302): "The observations should be continued to a short distance from the bottom, for in that region the velocities decrease rapidly." Dubuat found (*Principes Hydrauliques*, p. 100) that the velocity of translation of grains of sand in a small canal was only about three thousandths of an inch per second, where the lowest velocity measured by spheres $\frac{1}{4}$ inch in diameter was one foot per second. Most European observations confirm the above, but if the "new theories" are correct, the bottom of the Mississippi must be formed of adamant, unless the friction usually found there is absorbed at the surface in the work of lowering the maximum velocity to three tenths the depth. Although none of the observations on the rivers connecting the Great Lakes were as bad as some of the 69 selected verticals, yet as the use of the double float had led to such improbable results, and as in the mean time the telegraphic metre was invented, the latter was used exclusively in the continuance of the work. A series of comparisons was made between the floats and metre at different depths, where the surface velocity was nearly four feet per second, and the depth of the river about 50 feet. At the surface, and for ten feet below, there was but little difference in the velocity given by either, but at 45 feet the floats ran six tenths of a foot per second faster than the velocity shown by the metre, the action of the current on the connecting cord apparently raising the lower float, and thus showing too great a velocity. Afterward, Prof. S. W. Robinson mathematically demonstrated the position of the lower float at different depths, showing that it mainly depended upon the length and size of the connecting cord (*Flow of Water in Rivers and Canals*, p. 75; and Van Nostrand's *Engineering Magazine*, vol. xiii, p. 99). It was also found that the ellipse with the minor axis a little below the surface, used by M. Racourt in the reduction of his observations on the Neva (the only European observations on a deep river), would best agree with the observed change in velocities from the surface to the bottom. These results, unwisely perhaps, were published in General Reynolds' reports of 1868 and 1869, and the General was as soon as possible removed from the charge of the Lake Survey.

A month after his removal, General Humphreys, Chief of Engineers, ordered General Abbot to review them, and the first intimation that General Reynolds had of the dire offence he had committed was the publication of these reviews, and when he forwarded a reply to the Department it was returned, and he was informed that one officer could not review the work of another without being called upon to do so by the proper authority. A copy of the reviews was, however, furnished his successor, and the investigations and work on a final report immediately stopped.

And now in the report of the Chief of Engineers for 1875 is a record of a series of current observations on the Connecticut River, made by General Theo. G. Ellis, under the direction of General G. R. Warren, Corps of Engineers, which are such a remarkable confirmation of the correctness of the form of the velocity curve deduced from the metre observations above noted, that it seems as if they should be more widely known than they can be in that report, where the few grains of wheat are so unexpected and so seldom searched for.

TABLE I.—MEANS OF VELOCITY OBSERVATIONS ON THE CONNECTICUT TAKEN AT TENTHS OF DEPTH.

Tenths of Depth.	Means of all Float Observations. Feet per sec.	Means of all Metre Observations. Feet per sec.	Means of all Observations. Feet per sec.
Surface.	2.38	2.05	2.10
1	2.38	2.12	2.17
2	2.35	2.15	2.19
3	2.35	2.13	2.17
4	2.30	2.09	2.12
5	2.23	2.01	2.05
6	2.15	1.93	1.97
7	2.04	1.81	1.85
8	1.90	1.67	1.71
9	1.66	1.47	1.50
Bottom.	1.18	0.96	1.00
Mean.	2.084	1.853	1.894
Mean of Parabola.	2.114	1.887	1.928

They were mostly obtained by the use of metres, the telegraphic metre being preferred, though a few of the measurements were made with the double float. The final results are given in Table I., copied from a table in General Ellis's report (p. 344). These means were obtained by plotting the observations on a large scale, drawing a free-hand curve through as many of the points as possible, dividing the distance between surface and bottom by horizontal lines drawn at tenths of depth, and noting the points of intersection with the curve.

This method of interpolation was the same as that used by

Humphreys and Abbot, and though it can never give a true mean of the velocities, and if the person drawing the free-hand curve has a preconceived idea of the form it ought to assume may be very inaccurate, yet where there are so few missing observations, and the whole work is so carefully done as this on the Connecticut appears to be, the error may not exceed the errors of observation.

The first glance at these means shows a curious anomaly, the float observations giving the maximum velocity at the surface, while the metre shows it two tenths of the depth below.

Now, as we have seen, if floats can be relied on at all, they must be most correct near the surface, and, therefore, there must be some error in the metre measurements. Looking further, we find that in obtaining the coefficient of the metres by drawing them at different velocities through still water, General Ellis so feared the "pushing effect" of the boat that he suspended them five feet in front of it; while when making current measurements from the stern of an anchored boat, he entirely disregarded its retarding influence on the water passing under it, and neglected the writer's advice to hang the metre out from one side of the boat, when attempting to observe in the upper five feet of the stream. Again, the recorded observations show a more rapid decrease of velocity near the bottom than is given in the means. But as there are too few observations at any one depth to eliminate the errors, to find the true form of the top and bottom of the curve, the mean of all the float observations for the upper five feet, and of the metre observations for the lower five feet must be taken. These means are given in the following tables:

TABLE II.—MEANS OF ALL FLOAT OBSERVATIONS FOR FIVE FEET BELOW SURFACE.

Depth.	Velocity. Feet per sec.
0.35 feet below surface.	2.47
1.0 " " "	2.47
2.0 " " "	2.46
3.0 " " "	2.42
4.0 " " "	2.42
5.0 " " "	2.38

TABLE III.—MEANS OF ALL METRE OBSERVATIONS FOR FIVE FEET ABOVE BOTTOM.

Depth.	Velocity. Feet per sec.
5.0 feet above bottom.	1.94
4.0 " " "	1.88
3.0 " " "	1.78
2.0 " " "	1.63
1.0 " " "	1.41
0.4 " " "	1.20

In the following table, the means given in the last column of Table I. are thus corrected near the surface and bottom; the remainder being assumed to be correct, as they can differ but little from a straight line.

TABLE IV.—CORRECTED MEANS COMPARED WITH VELOCITY CURVES.

Tenths of Depth.	Corrected means of all observations. Feet per sec.	Ordinates of Racourt's Ellipse.	Difference from observations.	Ordinates of H. & A. parabola.	Difference from observations.
Surface.	2.23	2.23	0	2.16	-0.07
0.17	2.23	2.23	0	2.16	-0.07
1	2.22	2.22	0	2.17	-0.05
2	2.19	2.20	+0.01	2.16	-0.03
3	2.17	2.17	0	2.15	-0.02
4	2.12	2.12	0	2.11	-0.01
5	2.05	2.06	+0.01	2.05	0
6	1.97	1.97	0	1.95	-0.02
7	1.85	1.85	0	1.83	-0.02
8	1.71	1.69	-0.02	1.70	-0.01
9	1.46	1.46	0	1.56	+0.10
9.5	1.24	1.30	+0.06	1.50	+0.26
9.8	1.03	1.14	+0.11	1.45	+0.42
Bottom.	0.80	0.87	+0.07	1.42	+0.62

In the third column of this table the ordinates of an ellipse are given, calculated by the equation of an ellipse referred to the vertex of its major axis: $X = \frac{B}{A}(2Ay - y^2)$

$\frac{1}{2} + C$; in which $A = 9.75$, $B = 1.36$, and $C = 0.87$. This differs but very little from the corrected means except near the bottom, where the velocity is slower than is shown by the ellipse. Probably were the actual bottom velocity known, it would be still less than that given, and doubtless no simple curve can ever be found to correctly express the decrease in velocity near the bottom. In the fifth column, the ordinates of a Humphreys and Abbot parabola are given. From mid depth down this is nearly a straight line, cutting the bottom at an obtuse angle. At the surface it differs considerably from the means, agreeing passably well with them in the centre, but near the bottom it is shown to be the worst imaginable form of curve to express the decrease in that region. In his report accompanying those observations, General Warren says (p. 301): "One of the most important conclusions reached by this is, that both floats and metres give concordant results, showing that each is reliable when carefully and intelligently employed." The floats used in the determination of the outflow of the Lakes were connected by a cord one twelfth of an inch in diameter, and at a depth of 20 feet they gave a velocity less than two tenths of a foot per second greater than the metre; while in these Connecticut observations, where the depth did not exceed 23 feet, a cord only 0.036 inch could be used, and the difference should be proportionately less, as the observations show.

But on the Mississippi, where the depth was often over 100 feet, a rope a quarter of an inch in diameter, or seven times the size of the latter, was considered necessary, and the errors must have been proportionately greater. Possibly, however, the floats were not "intelligently employed" there. General Warren's next conclusion shows how a perfectly fair man may be misled by specious arguments in an intentionally false report, unless he examines for himself the data upon which it is based. "Another most important conclusion from these results (at least to those who have felt doubts) is the full confirmation they afford to the parabolic form of the curve of subsurface velocities as shown in the *Physics and Hydraulics of the Mississippi* by Humphreys and Abbot. . . . An attentive perusal and examination of General Ellis's report will not therefore enable one to do justice to this subject. I will not therefore attempt an abstract of it, but will give here but one diagram, showing how well the results of his observations conform to the curve of the parabola given by Humphreys and Abbot's formula. The diagram is No. 9 of Ellis's

report." The ordinates of the parabola given in Table IV. are taken from this diagram. It is also shown by the full line in the figure, the circumscribed dots being the corrected means, the crosses near the surface and bottom the uncorrected means from Table I., the curve of the ellipse being also given by the broken line.

The arithmetical sum of the differences between the corrected means and the parabola at the tenths of depth is 0.95, and between them and the ellipse at the same points only 0.13, or less than one seventh the former. The next paragraph to the one above quoted shows how completely General Warren was deceived by the apparent honesty of the report, and how little he examined the details. "The maximum discrepancy is only seven hundredths of a foot per second." A simple inspection of the diagram given would have shown him that the bottom velocity, as plotted, was over forty hundredths of a foot per second from the point where the curve cuts the bottom.

And did General Ellis receive his reward? Yes; in an addenda to the report, General Humphreys says: "The most accurate observations made since [the Mississippi survey] in this country, on a river the character of which admitted of the most refined mechanisms being used—that is, the observations made by General Ellis's party on the Connecticut River—confirm the laws deduced from the Mississippi observations." Unfortunately the observations on the outflow of the lakes did not "confirm the laws," etc., and General Abbot, in his review of General Reynolds' reports, says (Report of Chief of Engineers, 1870): "Let us now consider Assistant Henry's metre. Never having seen the instrument used, I can not form an opinion respecting its relative merit compared with the older types, but from his description it appears to be equal, if not superior, to the best of them. He has certainly obtained by its aid some interesting and novel data respecting pulsations in flowing water. . . . In my opinion, founded on a somewhat close study of the subject, instruments of this class are pretty toys, which have contributed more to retard the progress of discovery in the science of river hydraulics than any other cause. This is due to the fact that they register their results in a kind of cypher to which we can by no means be sure that we possess the key."

That by its use in a proper manner a tolerably correct idea of the discharge of a river may be obtained, is not improbable; but that by its aid it is possible to determine in a scientific manner so delicate a change in the velocity as that existing between the surface and the bottom, is doubted. The errors of the double float may be cancelled by multiplying the observations, but errors in the coefficient of the metre always act in the same direction under similar circumstances, and can not, therefore, thus be annulled."

How easily the "key" to this "pretty toy" is found and its "errors annulled," when a person is discovered who will report that his observations "confirm the laws," etc. It has been assumed throughout this paper that the telegraphic metre used in the Connecticut was the same as that previously described in General Reynolds' report, and in fact the plates accompanying General Ellis's report are almost an exact copy of those published in the *Journal of the Franklin Institute*, and as a frontispiece to flow of water in rivers and canals, even to the method of observing; but the only thing General Ellis says about it is: "The second current metre used was one constructed especially to avoid some of the difficulties usually encountered with such instruments. . . . In order to have as little friction as possible, the apparatus was made to record by breaks in an electric current." It is fortunate that the metre was used by one who could bring himself to make such a report that his observations would be allowed to be so fully published, otherwise this remarkable confirmation of the correctness of Racourt's ellipse in expressing the vertical velocity curve might have been utterly lost to science. Let all who are engaged on such work in the future, from this shining example, "learn to bend the pliant hinges of the knee, that thrift may follow fawning."

But may we not be entirely mistaken in General Humphreys' position in this matter?

His addenda to the report of General Ellis, which is apparently an answer to the objections to the use of the double float, would seem to confirm this view; for it is so weak that it could never have been seriously written.

The only point made in it is that as the rod on the upper float was always vertical, the connecting cord could not have had any dragging effect upon it, as in that case it should have inclined down stream.

Now if he really believes that the maximum velocity is three tenths of the depth below the surface, would he not have said that the effect of the cord would have been to incline the rod up stream? If this is the true cause of the publication of these observations, let us honor him for facing toward the right, and hope that some day he may be enabled to fully acknowledge his errors.