Durants (C.F.)

Aqueducts * * * * * * * *

(*From Hunts' Merchants' Magazine.*)

AQUEDUCTS AND CITY SEWERAGE.

FREEMAN HUNT, *Editor of the Merchants' Magazine.*

DEAR SIR:—Although the following paper was prepared with special reference to a system of sewerage contemplated by the municipal authorities, and laid before them on the 7th of June, 1853, it is, on account of the universal application of sewers to great cities, particularly appropriate for insertion in a journal like the *Merchants' Magazine*, which has ever been devoted to all topics pertaining directly or remotely to whatever contributes to the advancement of trade, industry, and the very existence of the marts of Commerce.

I will merely add, that in this communication I have endeavored to discuss the whole science of hydraulics upon which sewerage is founded, and with what success I leave to the judgment of the intelligent readers of the *Merchants' Magazine.*

Yours, &c.

JERSEY CITY, July 25. C. F. DURANT.

TO THE HON. THE MAYOR AND COMMON COUNCIL OF JERSEY CITY:—

A citizen of Jersey City, feeling a deep interest in its prosperity, and largely interested in the municipal taxes and assessments, begs to offer a few objections to the "Water Commissioners' report upon a plan of city sewerage."

The plan embraces a canal 100 feet wide, 2½ miles long, and 6 feet deep, on the north, west, and south boundaries of the city. The propositions submitted by the Commissioners in favor of adopting the canal plan, appear to be the following:—

"1st. Its economy.

2d. Its adaptation to the locality of Jersey City.

3d. Its decided superiority to any other system of drainage.

4th. The low land in the back part of the city will be increased in value, and made as accessible for boats as that bordering on the Hudson.

5th. It dispenses with vaults and cesspools and provides for the connection of privies.

6th. The cleansing is effected at a trifling expense.

7th. It is without any complicated mechanical contrivances.

8th. It will need but few repairs.

9th. It will in a few years increase the value of land in the western part of the city, by a sum far beyond the cost of its construction.

10th. Its other collateral advantages."

Of the ten foregoing propositions not one has been sustained, and I beg your indulgence to show that not one can be established. They are all fallacious, and, excepting the fourth proposition, not one has a seeming foundation in established facts.

First. Its economy, if it has any, must be inferred from the fact, if the fact exists, that the "flushing water" necessary to cleanse the sewers, will be had at less cost from the canal than from some other source. The commissioners have not stated the quantity of water required for flushing: indeed, they seem to express a doubt whether any water is required for that purpose when they say, "Perhaps the introduction of a small stream of water, constantly running, may be sufficient in itself to keep them clear of deposit." But, from their statements, we may compute the largest quantity that can be supplied by the canal to any sewer in any given time. The sewer at western boundary is 2 feet diameter in the clear; the bottom to be 1½ feet below meadow or high water. The inclination or fall in surface of canal at sewer, due to velocity on entering sewer, is not given; but we may assume it at 6 inches; this would allow the water to stand 1 foot deep, or to the center of the sewer. The velocity in sewer we may compute from the statements; sewer at Hudson street, 6,000 feet distant from canal, to be 1 foot below low water of the medium 5 foot tide. As sewers below low water are not known to be used or useful in any enlightened country, it may be presumed that the commissioners, on second thought, will place it at low water: this will give an inclination of 3½ feet in 6,000, or 1 in 1,714, or .00058 per foot. Then, by Dubuat's laws, represented in the formula $I = \frac{V^2}{C\,R}$ where I is the surface inclination, V the velocity per second, C a constant coefficient of 10,000, and R the mean radius, all in unity, we have $V = (\sqrt{C\,R\,I}) = 1.7$ and the 2 feet sewer at canal filled to center, or a sectional area of $(\frac{2^2 \times .7854}{2}) = 1.57$ and hence requiring $\overline{V \text{ time } 1.57} =$ 9,608 cubic feet per hour, which is ample time, and all the time that can be daily economically employed in flushing sewers that terminate at or below low water mark. In a former statement, it appears that the city will have many times 9,608 cubic feet of water daily, more than is required for

many years to come; and this abundant and superabundant fresh water has already been paid for, or contracted to be paid for, so that it will cost nothing, or at least the turning a stop cock to allow 9,608 cubic feet of it to run in one sewer each day, if attended with 75 cents cost, cannot equal $73,414, the estimated cost of the canal; and, therefore, the canal plan has *not* "economy in favor of its adoption."

Second. The only adaptation of the canal to the sewers, is that it can furnish, at high water or low water, 9,608 cubic feet of flushing water, for one hour per day, to each sewer laid on a grade which the commissioners deem best adapted to the locality of Jersey City. Now, the sewers which the commissioners submit as the best, may require for flushing and scouring, that the water shall move with a velocity greater than 1.7 feet per second. But by the physical law that governs its flow, and by the elements given, the canal cannot supply water to move faster than 1.7 in the sewers, while the water which the city is bringing from another county can, on account of its elevated surface, furnish a current much greater than 1.7 feet per second in the sewers. And therefore, the canal plan is *not* "adapted to the locality of Jersey City," because the surface of canal is *not* adapted to the grade of sewers which the commissioners offer as the best for the locality.

Third. The decided superiority in one plan over another should be manifested by some token of cheapness, beauty, durability, or other commendable quality. So far as the canal is concerned in the drainage of Jersey City, it certainly will cost all that it has been estimated at, without furnishing water at a greater velocity or of a better quality than from a cheaper source. It will hardly be deemed an ornament even by the commissioners. The estimates provide for plank and other timber, though nothing is said about fifty, more or less, street drawbridges, which would probably decay as soon as the stone reservoir on Bergen hill. The commissioners have not named any other decided merit in the canal, and as no other decided merit appears in the report or map, it is safe to conclude that the canal system has *no* "decided superiority over any other system of drainage."

Fourth. It is said "the low land in the back part of the city will be increased in value." That is plausible to some, and may be true. But that has nothing to do with the system of sewerage. If the owners of low land in the back part of the city desire to build a canal to increase the value of their land, the legislature may grant them permission to do so, under proper restrictions, but it is not probable that they would be permitted to levy a tax on the high land at the front part of the city to pay the interest or principal of its cost in construction. If all the owners of land through which such a canal might pass should join in the speculation, there would certainly remain adverse interests and rights that would require some attention. The owners of property on the eastern slope of Bergen hill might legally claim the right to use the canal as a common sewer, to receive the wash from their privies, cesspools, and other sewerage matter. The citizens of Jersey City might reasonably object to such an open receptacle of filth surrounding them on the land side with mephitic odors. The traveling public and the grand jury of the county might need to be consulted on the form, dimensions, and structure of the numerous street bridges to be erected and maintained. When all these conflicting interests have been reconciled, it will remain an open question whether the value of the low lands in the back part of the city will be increased by the operation. And, on a canal with twenty or more drawbridges, and a five foot tide at high water only

the low lands in the back part of the city will *not* "be made as accessible for boats as that bordering on the Hudson," where more than five feet can be had, and accessible at all hours. There are, probably, not two men in the city who would deem their lands increased in value by a canal: and if an attempt is made to carry out the projected scheme of the commissioners, they will probably find themselves legally bound in damages for the land occupied by the canal, at the rate of 250 dollars the lot of 25 by 100 feet, or, including streets for the whole route of 2½ miles, at the rate of 200 dollars per lot, amounting to 105,600 dollars, to be added to their imperfect estimate of 73,414, making the sum of 179,014 dollars, besides some fifty drawbridges that have been strangely omitted in the estimated cost of a canal that is supposed will increase the value of low land in the back part of the city.

Fifth. Any system of sewerage may "dispense with vaults and cesspools." It is only necessary for those who frame the system to say they are dispensed with, and it is done. The framers may also provide for the connection of privies, and it is at once provided for. But in those cases the whole is done by the framers of the system, and whether well or badly done might be a subject for discussion when we see what has been done, and what facilities were at hand for doing the work. But when the commissioners say, "it, [meaning, as understood, *it*, the canal,] dispenses with vaults and cesspools, and provides for the connection of privies," they are giving a character and credit to the canal that is not due to it, and which is not shown to be due to it by any fact or any element in their report. If inclination, or water, or velocity in sewers, are the essential elements for performing those parts of the system, then the Passaic water, abundant and most elevated, was *more* efficacious than the canal. And hence, "*it*," the canal, does *not* "dispense with vaults and cesspools," and "it" does *not* "provide for the connection of privies."

Sixth. "The cleansing is [not] effected at a trifling expense," when the canal, constructed for the sole purpose of cleansing the sewers, is shown, by corrected estimates, to cost 179,014 dollars, with a probable addition of 50,000 dollars for drawbridges, and an annual outlay of at least 6,000 dollars for repairs and attendance. The annual repairs will represent a capital of 100,000 dollars, making a grand total of 329,014 dollars, or the interest of that sum, as the annual cost of cleansing the sewers. It is certainly *not* a "trifling" sum to pay for cleansing sewers. Especially, when we have the means at hand for cleansing them without cost, or without any additional cost to that which is already incurred for the introduction of the Passaic water.

Seventh. There is a certain degree of complication about canals in general, and the one proposed by the commissioners is not an exception to the general rule. Its construction is compounded of digging, piling, bracing, planking, arching, or tunneling under one or more railroads; drawbridges for all low streets, and arches for all roads and streets at the foot of Bergen hill; and two tide-gates, which, on account of the precarious soil in their localities, will require the best mechanical and engineering skill in all the board of commissioners to make them efficient and durable. And, however introduced into the head of sewers, the water will require stop-cocks, cranks, or sliding gates, so that "it is [*not*] without any complicated mechanical contrivances."

Eighth. Those portions of piles and pine planking that are above water,

together with the timber in bridges and tide-gates, will decay, and need entire renewal in periods of less than ten years. The 6 feet 4 inches of solid earth to raise the meadow up to the grade which the commissioners lay down in their system of sewerage, will, judging from the railroad filling, so press downward, lateral, and upward, at and in the canal, as to fill it entire with mud in periods of less than five years. So that, in periods averaging seven and a half years, at least two thirds of estimated cost of canal, aside from the fee to lands, must be paid for over again. And therefore, if the commissioners mean the word "*few*" to apply to the unit of our money, or to hundreds, or thousands of dollars, then their statement that "it will need but few repairs," is *not* sustained by any elements or any facts in or out of their report on a system of sewerage.

Ninth. With and without canals, real estate, including the low lands in the back part and in the front part of American cities, has, within a few years, generally increased very much in value. The cause, or combined series of causes, that raised the land to its present increased value, are, at the present time, supposed to be well understood by many men. A few claim to have foreseen, and years ago predicted, the result. The elements for almost prophetic vision, no doubt existed before the present century began; and it is barely possible that some comprehensive minds, well trained and well balanced, did long ago see the elements in such clear and distinct outline, as to predict the precise present value of each city and of each particular district and building lot. The subject is certainly prolific of thought and of words. It is not without interest, and may at proper times, on suitable occasions, be discussed with some profit. Experience shows that some canals have increased the value of property, while others have lessened it. The Erie and the Morris are vivid illustrations of their particular adaptations and influences. The canal in Newark is generally deemed a nuisance; property on its border can be now rented or purchased at less price than that which is more distant. Bergen street has all the advantages of the southern bay. Property in that locality should be the most valuable and most desirable for residences. But the Morris canal passes through it, and the lots are now held at less price than those in any other upland part of the old city limits. Experience shows that if the canal was filled up to-day, the property on its border would rise 25 per cent in value to-morrow. If the commissioners will admit of a substance in place of a name, then we have the required elements for predicting the probable and comparative value of land on the border of the canal in the western part of the city for "a few years" and for the next half century. The present Mill creek occupies the site of the contemplated canal: it is open to navigation nearly the entire length, except where the railroad crossing has pressed it out of existence. It has all the characteristics of a canal except in name. Let us call it a canal? It has been a canal of as great capacity as the Morris canal for more than fifty years. It runs through the low land in the western part of city. Its navigation has never been disputed; and yet property on its border is now offered at the lowest, much the lowest prices, of any in the city. For the past few years, and for the past fifty years, property has risen *less* on the border of Mill creek than it has in every other part of the city more distant from it. And therefore, every available element shows that the *canal* "will [*not*] in a few years increase the value of land in the western part of the city by a sum far beyond the cost of its construction."

Tenth. "Its other collateral advantages" have not been made apparent by

any showing of the commissioners; their entire report has been read carefully, and in vain, to find the least hint or allusion to what is meant by "other collateral advantages." The idea has suggested itself that perhaps the prospective revenues in the form of canal tolls, were intended to be covered by "other collaterals." This hypothesis is strengthened by the fact that a subsequent statement from the commissioners to your honorable body suggests the appointment of toll-gatherers, and provides ways and means for the surplus or deficient receipts. Assuming *tolls* to be the meaning of "other collaterals," then we have the required elements at hand to compute the exact amount of revenue to deduct from the interest of $329,014, the approximate cost of its construction. For a canal of 2½ miles in length, and tide gates a mile apart, it would not be prudent to appoint less than two toll gatherers, at a salary of five hundred dollars each. Less than two might be a serious hindrance to navigation in case a vessel arrived at the Communipaw gate while the toll gatherer, if but one, happened to be at the Hoboken cove gate. Before he could receive official notice that a boat was waiting his kind offices at the southern gate, the high tide that never waits, would have passed away, and the boat, if it had round bottom, would have careened over to dump the deck load into the mud. It is not certain, however, that the city or the commissioners would be liable in damages for the loss of the deck load; because it is not probable that a boat would ever enter the canal. The creek has been open and free to navigation for the last fifty years, without receiving a customer, and it is not probable that the custom would increase in the next fifty years, even if the name is changed from "Mill Creek" to "Canal." There has been a large oakum factory on the creek for several years. The owners, Davy & Mills, have all the depth of water that the canal plan can give, and yet they prefer to use carts instead of boats to transport their goods to New York. Such would probably be the practice of every manufacturer who chose to locate in the western part of the city. And hence, there would be no boats to enter, and no tolls to receive. And hence, it has *no* "other collateral advantages." But the salaries of the toll gatherers must be paid in cash or bonds, making $1,000 to add to the former estimate, or the round sum of $330,000 to build a canal which can furnish flushing water at a velocity of only $1\frac{7}{10}$ feet per second, when 2½ or 3 feet per second is declared to be required; and when more than 3 feet per second could be had by paying a man seventy-five cents for turning a stop-cock one hour each day.

There are some collateral statements in the commissioners' report that show a high degree of hasty and careless computation. A degree of carelessness that is almost unpardonable when it relates to a system of drainage involving an expenditure of half a million of dollars for sewers, besides a greater amount in raising the streets to meet a convenient grade. There was no necessity for discussing what they call the "first plan," unless they intended to recommend it for adoption. In condemning it, there was no necessity for carelessly misrepresenting it. It does *not* require "the marsh west of Coles street to be raised 16 feet;" it does *not* require any street or part of street "to be raised 16 feet." It does *not* require "the drains to discharge 3 feet under high water." It does *not* require "the bottom of drain at foot of Bergen hill to be 9¼ feet above the marsh level." And it does *not* require "7 feet for hight of drain and the requisite covering of earth." If the canal plan can discharge 1 foot below low water, surely the "first plan" can, with perfect safety, discharge at low water. If the canal plan

can begin with a 2 feet drain, and if the so called "new system" shows "much smaller pipe drains to be more efficient when flushing cannot be resorted to," then certainly a 1 foot pipe drain will apply to the "first plan" the first thousand feet, where the drainage comprises a very few acres. Then 2½ inches per 100 feet, is 12½ feet for 6,000 feet, or 7½ feet, *not* "9½ feet" above a 5 foot tide or meadow, and 2 feet more will cover the pipe a foot at top, making 9½ feet instead of "16 feet" for the highest grade of any point west of Coles street.

If the raising of streets is enough to render the adoption of the first plan "impracticable," then the same argument should apply to the canal plan. Because the canal plan proposed to raise the streets west of Coles street 6 feet 4 inches, which is within 3 feet 2 inches of that required for the first plan. Again, on what authority? on what facts? on what elements do the commissioners recommend the streets to be raised "6 feet 4 inches" for a particular canal plan, and in the same report, declare the raising of streets for a first plan to be "*impracticable?*" Your honorable body hold the recorded fact that parts of Warren and Grand streets were *practically* raised more than 12 feet. Much of the dirt to raise those streets was brought from *beyond and through* the low lands in the back part of the city. That fact is an important element to show the *practicability* of raising any street "west [or east] of Coles street."

Collateral to this subject are the commissioners' statements about the merits of the old and new systems; and the previous want of information that is now furnished by a Mr. Roe, Mr. Gotto, and others, through the London Board of Health and Metropolitan Sanatary Committee, to whose united labors the world is indebted for "the most valuable information now to be obtained upon this subject, as well as for the improved system of small drains, &c." These deliberate and profuse statements, unless they are shown to be erroneous, may lead into great errors and great waste of money in constructing canals and sewers and aqueducts, in violation of the well established and well known principle or physical law that governs the flow of water.

It is a mistake to suppose that the low districts in and about London are similarly situated to Jersey City. If the low land in and about both London and Jersey City were level with high water, that would *not* be "similarly situated" with regard to drainage by flushing with a tide canal or tide water. Because in flushing, as in running water, inclination of surface is an essential, an indispensable, an *imperative* element. The inclination, in such cases, can be found only in the difference of surface level between high and low water marks. And, as London gives 19 feet, while Jersey City gives 5 feet, they are therefore *not* "similar," because one is nearly four times greater than the other.

It is an error to suppose that "the best evidence given before the parliamentary committees, and referring to our own experience in this country, that the minimum descent necessary to be given to drains to prevent an accumulation of deposit, where an additional quantity of water cannot be had, is found to be 5 inches in 100 feet." The words "additional quantity" are not well understood; but suppose the meaning is, additional quantity of water to that furnished by the rains or soil of a particular district; then the whole statement falls by its own gravity. For, in the same report, we are told that Mr. Phillips and Mr. Gotto, who appear to be very respectable witnesses, say or testify that "in main sewers, with good depth of water, [no matter

where they get it,] 1 in 1,000 is allowed." Now, if "good depth of water" is the great requisite, and if Jersey City has no springs or soil, or rains, or water works, to furnish it, what can prevent a main sewer from Mill Creek to the Hudson, starting 3 feet below low water, and rising 1 in 1,000, or 6 feet in 6,000 feet to Mill Creek, where it will stand 3 feet above low water, and be sure to have a *very* "good depth of water" for 20 out of every 24 hours during each day. That will satisfy all the requisites of the London committee. And besides, it appears that the experience of commissioners in this country, enables them to say that a main sewer discharging 1 foot below low water, and rising to $1\frac{1}{2}$ feet below a five foot tide at a canal 6,000 feet distant, or with a rise of 1 in 1,333, "may, perhaps, be kept clear of deposit by a *small* stream of water constantly running." Now again, if there should happen to be no rains, and no canal, but a half dozen or more houses at the upper end of the sewer, and using enough Passaic water to keep a *small* stream of water constantly running, then *without* "an additional quantity of water," the small constant stream "will, perhaps, keep it free from deposit." So that the statement about 5 inches in 100 feet being the minimum descent required by the English and American testimony and experience, to keep a sewer free from deposit, was a mistake of the commissioners, and is virtually withdrawn by those who presented it.

It is, probably, true that "in all the English reports upon the subject of sewerage, which have been published up to 1850, there is a want of that definite information upon which a correct decision could be formed upon the size of the sewer and the requisite inclination necessary for draining any given locality." But it is *not* true that "this information has been very recently furnished by Mr. Roe, and published in the Report of the Board of Health for 1852." The "definite information" from Mr. Roe, appears from the commissioners' report, to be tables giving the diameters, level, and inclination of sewers and drains to convey away rain and other water, from acres of land and numbers of houses; and, they are said to be results of observations extending over a period of 20 years, in the Holborn and Finsbury divisions.

So far, the information is "definite." But there is *not* a particle of information, "definite" or indefinite, in the tables, "upon which a correct decision could be formed upon the size of the sewer and the requisite inclination for draining any given locality." It contains *not* one correct requisite element: not *one*. The quantity of water falling on a particular number of acres and particular soil and locality, is definite information, for some definite purposes; but the quantity of water that reaches one point of the sewer in any given time, is the essential element in constructing sewers. This is not furnished in the tables. The quantity of water, *with inclination of surface*, and time of passing a point or section of any sewer whose diameter and form, or area, is given, are definite and essential elements "upon which a correct decision could be formed." But there is *none* of this in the tables, and there is no information in the tables from which these essential elements can be deduced. The tables not only lack every essential element to aid in constructing sewers or aqueducts, but they also show a lamentable carelessness or deplorable ignorance of the most common rules in arithmetic: they have no relation to science and are not consistent with themselves or their parts. They provide for draining from 10,100 down to 38.$\frac{3}{4}$ acres of land, watered with one inch of rain in the hour, by sewers on a dead *level*, and by others inclined from 1 to 480 to various inclinations, and with various diameters.

The $\frac{3}{4}$ parts of an acre are probably inserted to show that with a little fractional arithmetic and 20 years of devoted labor, water may be made to run with a dead *level surface*, provided acres and fractions of acres are substituted for feet or gallons of water. To show the superior advantages of the new dead level system in creating velocity as a motor to scour and extinguish steam, they give sewers of 2, 4, and 8 feet diameter, whose areas are 3.1, 12.5, and 50.2, respectively, or whose sectional areas are as 1 to 4, and make them discharge 38.$\frac{3}{4}$, 277, and 2,850 acres of water, whose cubical contents are as 1 to 7.1, and 1 to 10.25, respectively. Additional embellishments were deemed essential to meet favor with the learned of two hemispheres; more figures and more arithmetic must adorn the columns: acres and fractional parts of acres must also be represented by equal areas "in squares of 100 feet." One acre was found by other similar tables to contain 448 instead of 435 of such squares, and hence, by the new system of water running with a dead level surface, the $\frac{1}{4}$, the $\frac{7}{16}$, the $\frac{1}{2}$, 1.$\frac{1}{2}$, and 1.$\frac{3}{4}$ acres, are shown to contain 112, 195, 224, 528, and 814 respectively, and differing precisely 3, 4, 7, 6, and 29 respectively, from the old system of arithmetic which your honorable body, at a large annual cost, are endeavoring to promulgate through the public schools of the city.

In regard to the new system or plan submitted to your honorable body, the commissioners say "the average area drained by each of the main sewers and its collateral pipe drains, is about 60 acres, (see Appendix C:)" and they add, "The capacities of these sewers are in accordance with the recent tables of Mr. Roe, (see Appendix A.)" Now both of these statements may be true, but your honorable body will fail to perceive how any system, subject, or thing, can be in accordance with any other system, subject or thing, that is not in accordance with some known science, and is not in accordance with itself or its parts. If your honorable body should proceed one step further, with much less than critical examination, you will perceive that the recent tables of Mr. Roe provide for draining 67$\frac{1}{4}$ acres with a sewer only 30 inches or 2$\frac{1}{2}$ feet in diameter, and not the least inclined, but on a "*level*," while the commissioners state that "the average area drained by each of the main sewers and its collateral pipe drains, is about 60 acres," with sewers of from 2 to 3 feet in diameter, and manifold inclinations from 1 in 1,714 to 1 in 54. In the diameter of the sewers and in the number of acres to be drained, there is indeed a seeming accordance, but in the *level* and the *inclinations* there is evidently a perfect discord. And now, if your honorable body should strive to make concord by joining a smooth, placid canal to the discordant inclinations, then the modest facts cannot be reconciled with the statement; because the recent tables of Mr. Roe provide for draining 67$\frac{1}{4}$ acres, without a canal and without inclinations.

The commissioners offer some remarkable evidences of the supposed facts on which their new and improved system of drainage is founded. We are gravely told, "it was found by the trial works that the addition of eight junctions, each of 3 inches diameter, to a main line of only 4 inches diameter, so increased the velocity of the stream that there was no increase of its sectional area." If that statement is true—if that is a fact, an established fact—then, by every rule of every science known in London or Jersey City, 8,000 or 800,000 junctions, each of 3 inches diameter, will so increase the velocity that there will be no increase of the sectional area. Now, for convenience of computation, let us make inch the unit; allow all the sewers to remain filled to center only, and to have an initial velocity V, of 12 inches

or 1 foot per second. Then $\frac{4^2 \times .7854}{2}$ must equal S, the sectional area of main line, and $\frac{3^2 \times .7854}{2}$ must equal s, the sectional area of 3-inch junction lines. Make the eight hundred thousand junction lines equal n, and we have $\frac{n\ (s = 3.5343)}{(S = 6.2832)} = V = (\frac{450000}{m = 5280}) = 450000$ feet or 85.2272 miles per second. A formidable velocity surely; and if such a sewer, or system of sewers, should point towards the enemy's ships, there is no telling the incalculable damage which the pebble stones and brickbats floating in the current may cause to the sails and rigging.

The commissioners tell us, that "for the solution of this, facts are more valuable than theory." Our acknowledged head of lexicographers gives more than one meaning to the word "*theory*." In one sense it is a combination of numerous unmistakeable facts, all agreeing and showing a mathematical law, principle, or theory, that is unmistakeable, undisputed, and undisputable. In another sense it is a scheme, hypothesis, or conjecture, subsisting only in the mind. If the latter meaning was intended by the commissioners, then we can estimate the propriety of building a canal, and its force in argument, to show how Jersey City may "become a successful rival to its neighbors." The success in rivalry not being shown by any facts that conform to the old system, must remain a theory or conjecture of the mind, unless the new system of canals and sewers, founded on the new facts in the recent tables, is pointed towards our rival over the way. *Such* a system, with the enormous velocity of 85 miles per second, if continued, and well supplied with pebbles, brickbats, and balls, would, no doubt, compel the inhabitants to vacate the island of warehouses, banks, and palaces, and leave us the undisputed, the unrivaled masters. No Mordecai could stay at the gate.

There is a general lack of elements in the report to show why new facts and new systems are better than old theory. With new facts or new elements, old theory may critically and mathematically examine new systems of small drains and short canals. The commissioners state the supposed facts exist, and state they find them in the tables. "Mr. Roe," we are told, (Mr. Roe!) "finds that sewers of much smaller sections than the *usual tables* indicate, are amply sufficient." And there they leave it. No elements are given to show *why* smaller drains are "*amply sufficient*." But, like the poor simple Esquimaux,

> "Whose soul, proud science never taught to stray
> Beyond the comet's path or milky-way,"

in warmly expressing his thanks and delight for a *bonne bouche* of tallow candle, train oil, or fish entrails, says, "*good! good!*" without the ability to express *why* it tastes "good!" or *why* it is "good! good!"

Again, the commissioners tell us that a Mr. Lovick made "tables." That "Mr. Lovick is a surveyor, attached to the Metropolitan commission of sewers, before the General Board of Health in 1850," and that "Mr. Lovick's tabular statement *discloses the fact*." What fact? After such an array of professorships and titles, we expect some tangible facts; some elementary disclosures that were coveted, courted, coaxed, drawn, wrung from Nature's arcana by the stern rules of Bacon, by the quick, deep-grasping

mind of Kepler, or by the slow, deliberate, patient, trained, sure, far-seeing mind of Dubuat. But no such thing—no such facts. "Mr. Lovick's tabular statement discloses the fact, that the sectional area of the old drains is to the improved system as 30 to 1." Coinciding almost exactly with the number of States to the American Union; and within a very small fraction of Grimalkin's statistics on black cats and white ones.

The parliamentary committee, the board of health, the commission and commissioners, with a long retinue of professors, surveyors, architects, and pipe-makers, perhaps, had heard that facts were sometimes disclosed by experiments with Nature: that blind alchymy had disclosed some material facts for the structure, theory, or science of chemistry; that the theory or science of astronomy is built on the observed motions of matter; and that the theory or science of hydraulics is built on the observed manifold facts in the measured operations of running water. And hence, *experiment* was deemed necessary to give an air of learning or science to new systems of tables and tabular statements of sewers and aqueducts. They directed Mr. Hale to experiment, they told him to "lay down a 12-inch pipe, 560 feet long, and build a wall at the end of it, so that the whole of the sewerage water of a 5 foot 6 inch sewer should pass through it." Mr. Lovick was sent to make a "*similar experiment*" with a 15-inch pipe on the bottom of a 3 by 5 feet sewer, "inclined 1 in 153 or somewhat less." They did not know that, building a wall at the head of the pipe to pond up the water, was an element of positive destruction to every essential element in any formula for the construction of sewers. It was like making the basement or first story of a house, a grand reservoir for water, whose perpendicular hight is the sole cause of all the velocity in pipes that discharge from it. They had heard that *inclination* was, in some form an element for the construction of sewers and aqueducts, and therefore, we are told "the sewer or pipe has a fall or inclination of 1 in 118, or somewhat less, 1 in 153." It does not seem to have been even a thought of their scientific minds, that the element "inclination," in formulæ for constructing sewers and aqueducts, relates to the *water* only, and means the inclined *surface* of the water only.

They had heard that hydraulics related in some way to the "science of drainage;" that there were things called formulæ, by which experts could compute the inclinations, dimensions, areas, velocities, and quantities of all things relating to sewers and aqueducts, comformably to some known theory or law of Nature. They, perchance, have seen some mathematical or theoretical formulæ, with a combination of unintelligible mixtures of figures and symbols, and, from their similarity to the tables, it is inferred that formula and table are synonymous. They build sewers and aqueducts, but they find the water does not flow in the way and manner in which they understood it would flow; that the flow does not conform to the tables; and that the tables are the same theory as the formulæ. And hence, without further authority, without one element or one fact to sustain the assertion, they declare that "a careful observation of the water passing through sewers, exposed so great a difference between the theoretical area and that actually required, that a system of trial works was commenced," &c., and, "in the Croton and Cochituate aqueducts, the practical velocity was found to exceed very considerably the theoretical; that of the Cochituate, where the inclination was only 3 inches per mile, being 1 foot per second, or an increase of $\frac{1}{3}$ over $\frac{7}{10}\frac{6}{0}$ of a foot, that deduced from the formula." It ap-

pears by the report, that "various formulæ had been in use for a long time for calculating the areas of sewers:" but we are not told how many formulæ, or what particular formula or table was used for calculating the areas of the Croton and Cochituate aqueducts. That more than one was used, we infer from the statement, that the practical velocity was found to exceed the theoretical "*very considerably*" in the Croton, and "1 foot per second, or an *increase* of $\frac{1}{3}$ over $\frac{7}{10}\frac{5}{0}$ of a foot in the Cochituate." That is not a very intelligible statement of the *difference* between the two, or of the precise difference between practice, and theory or science in either case. If "very considerably," and if "$\frac{1}{3}$ over $\frac{7}{10}\frac{5}{0}$ of a foot," both, or either of them could receive some definite mathematical value, there would still remain wanting several indispensable elements, by which to examine the degree of accuracy in the statement of precise variation between practice and theory in constructing those costly aqueducts.

The commissioners' report comes from those who profess to know the facts; from those who are presumed to know the facts; from those who, having been officially engaged on both of those important aqueducts, are presumed to speak from the *card;* to speak *ex cathedra.* Historically, we know that those who planned the structures and computed the velocities, fell short of the truth. It is also an historical fact, that the same guiding intellect that fell short of the truth in computations for the Croton, was *afterwards* employed as consulting engineer, at a large price, to compute the elements and flow of water in the Cochituate aqueduct, where, as appears by the commissioners' report now before you, the first great blunder, which amounted to something "*very considerably,*" was *increased* to an amount *greater* than "very considerably."

If "facts are more valuable than theory;" if theory and theoretical principles are at fault; if hydraulics is an uncertain theory; if science is not science; if there is any truth in all the statements submitted by the commissioners, then it will well become your honorable body to pause before you adopt a new system of sewers and canals, involving an expenditure of half a million of dollars, and based on pretended facts that are deliberately withheld from examination. The pretended facts, if they exist, are shown to cause great waste of money. For, it appears by the new system submitted for adoption, that the same facts were used in constructing the Croton aqueduct, at large unnecessary cost in providing for more water than was wanted or expected to flow; and, with that additional experience and fact, the same intellects constructed the Cochituate, at still greater waste of money, in providing for one-third more water than was wanted or bargained for. With the same facts and same rate of increased error, we may expect to learn that one half of the money, expended more wisely, would have been ample for the intended and computed velocity and quantity of water required in the system now submitted for approval.

It is always prudent to pause before you adopt any system of sewers and canals based on the hypothesis that established theory is not science. It may be that the established theory of hydraulics is an exact science; that it is a truth, one of the eternal truths, which, when fully understood by men, is called an exact science. The supposed new facts in the London experiments and experience, submitted by the commissioners, may be errors of conception. They are erroneously planned and erroneously inferred. They are not facts; they are palpable errors, that exist only in the imagination. The theory of hydraulics is founded on well-ascertained facts; on facts that

can be weighed and measured, and is therefore a mathematical science. It is founded on facts that were coveted, coaxed, and wrung from Nature, and therefore hydraulics is a natural science. It is an exact science. It embodies a revealed truth, an eternal truth, a physical law, a law of Nature, and is, therefore, a true science. It is an error to suppose that careful observations of water passing through sewers, exposes a difference between theoretical areas and that required in practice. It is simply *not* true that the practical velocities in the Croton and Cochituate aqueducts, were found to exceed the theoretical very considerably, or any quantity equal to the ten thousandth part of a hair. Water follows the eternal law, although man erroneously computes and builds channels that do not conform to the mathematical principles of the law. Those who construct aqueducts do not always understand the law, or have not the mental ability to measure and compute its mathematical principles. It is no excuse for those who read the English language to plead ignorance of Dubuat's laws. The substance, for half a century, has been published in their mother tongue by Dr. Robison, from the original French, in the Encyclopedia Britannica; and by Dr. Young, in the journals of the Royal Institution in 1802, from the German of a distinguished professor, to whom Dr. Young gave the credit of discovery, but subsequently published a correction of that error in Napier's Supplement to the Encyclopedia Britannica. Dubuat's laws are the foundation of all that is known to man of hydraulics, as Kepler's laws are the foundation of all that is known of astronomy. There would be no science in the name *astronomy* without Kepler's laws, and there would be no science in the name *hydraulics* without Dubuat's laws. The planets cannot move, and the water cannot run without those laws.

Yours, &c.,

JUNE 7th, 1853. C. F. DURANT.