THE

PORT FOLIO,

NEW SERIES,

BY OLIVER OLDSCHOOL, ESQ.

ASSISTED BY A CONFEDERACY OF GENTLEMEN.

Various; that the mind
Of desultory man, studious of change,
And pleas'd with novelty, may be indulged.
COWPER.

VOL. III.

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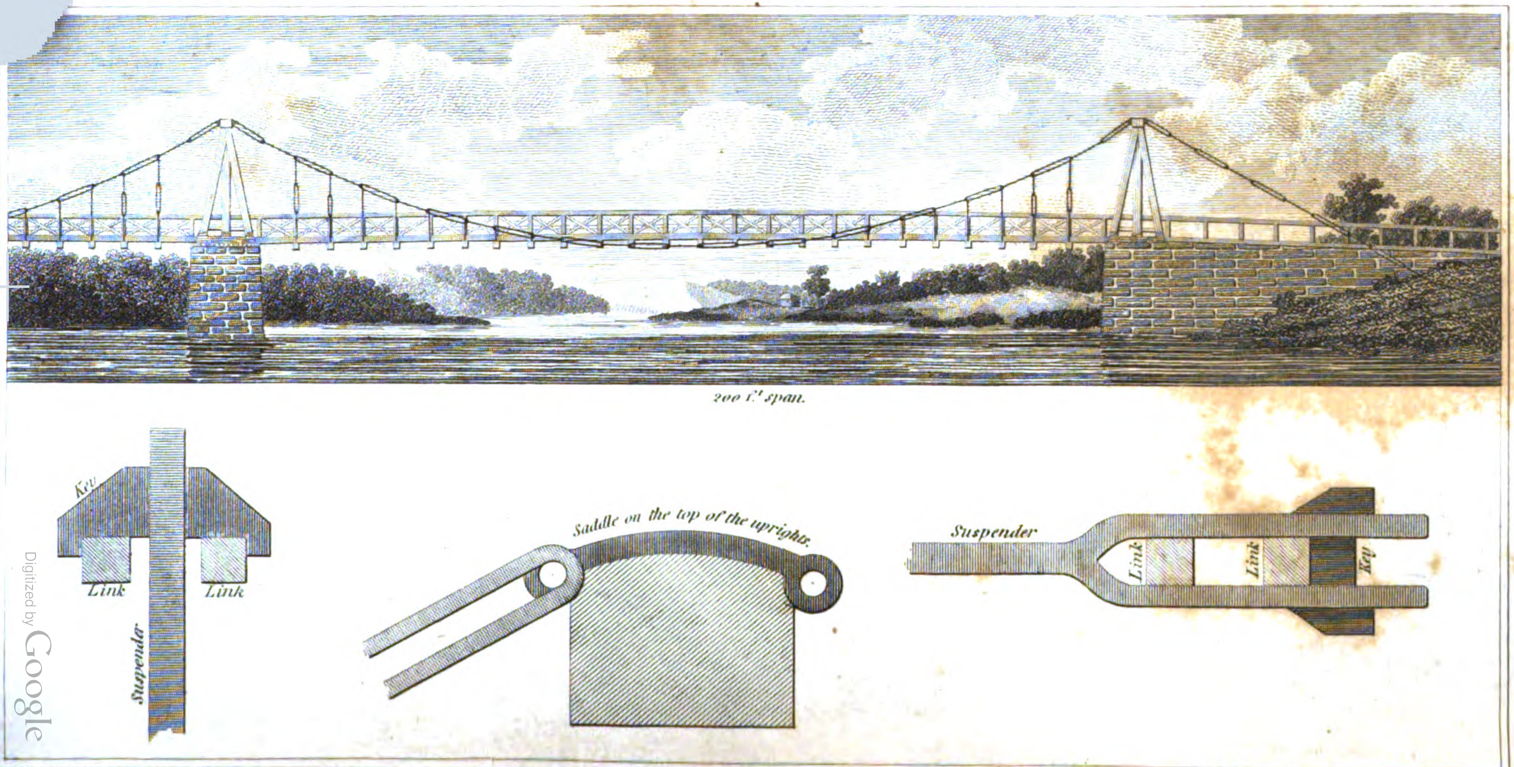

W^m Strickland del. B. Tanner f.

View of the Chain Bridge invented by James Finley Esq^r

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THE USEFUL ARTS—FOR THE PORT FOLIO.

A description of the patent Chain Bridge; invented by James Finley; of Fayette County, Pennsylvania. With data and remarks, illustrative of the power, cost, durability, and comparative superiority of this mode of bridging.

THE general satisfaction that this invention has given to all concerned, since its first introduction, in point of safety, simplicity, economy and duration, has animated me in this attempt to diffuse the knowledge of its principles; and perceiving the rapid strides it has lately made towards a general adoption, I am not without hopes of a patient hearing before a candid public; and that this project may yet materially subserve the internal interest of our country.

JAMES FINLEY.

DESCRIPTION.

THE bridge is solely supported by two iron chains, one on each side, the ends being well secured in the ground, and the chains raised over piers of a sufficient height erected on the abutments at each side, extended so slack as to describe a curve, so that the two middle joists of the lower tier may rest on the chains. The other joists of the same tier, are attached to the chains by iron pendants of different lengths so as to form a level of the whole. In order that the chain may support as much weight as it could bear, when hung with the weight attached to the end of it, the piers must be so high as to give the chain a sinking or curve of the one full seventh of the span. The ends of the chains must descend from the tops of the piers with the same inclination that they take inwards, until each end reaches the bottom of a digging, large enough to contain stones and other materials sufficient to counterbalance the weight of the bridge and what may chance to be thereon. The chains, if only one to a side, must be made with four branches at each end, to be let down through as many stones, and to be bolted below. These stones are laid flat on the bottom of the digging: other flat stones may be placed thereon, to bind and connect the whole, that they may have the same effect as a platform of one piece; four or more joists will be necessary for the upper tier—to extend from end to end of the bridge—each will consist of more than one piece; the pieces had best pass each other side by side, so that the ends may rest on different joists on the lower tier. The splice will then extend from one joist to another of the lower tier, and must be bolted together by one bolt at each end of the splice. The plank flooring is laid on this tier. It will be probably found most convenient that the chains be made with links as long as the space between the joists: every other suspender must attach to a link of the chain edge upwards, perhaps this may best be done by a clevis to go through the upper link of the suspender, and embrace the link of the chain and receive a key above—the other suspenders will come up through the flat links of the chain and receive a key above—the lower end of the lower link of the suspender may be made so wide as to receive the end of the lower tier of joists.

In the year 1801, I erected the first bridge on this construction over Jacob's creek, on a contract with Fayette and Westmoreland counties, to build a bridge of seventy feet span, twelve and a half feet wide, and warrant it for fifty years (all but the flooring) for the consideration of six hundred dollars. Nothing further of the kind was attempted for six years. The exclusive right was secured by patent in the year 1808.

There are eight of these bridges erected now; the largest of which is that at the Falls of Schuylkill, 306 feet span, aided by an intermediate pier; the passage eighteen feet wide, supported by two chains of inch and half square bar. There is also one at Cumberland (Maryland) supported by two chains of inch and quarter bar, span 130, width 15 feet. Another over the Potomack above the Federal city, of nearly the same dimensions as that at Cumberland. This season, one has been thrown over the Brandywine, at Wilmington, 145 feet span, supported by four chains of inch and $\frac{3}{8}$ths square bar, breadth 30 feet, it has two carriage ways, and one or two foot passages. There are two erected near Brownsville, in Fayette county, the spans 120 and 112 feet—inch and quarter iron, breadth 18 and 15 feet. There was one built last season over the Neshamany, in Buck's county, near 200 feet span, one pier. An incorporated company at Frankfort, have begun to build one over the Kentucky river, span 334 feet, with one pier. Another incorporated company at Pauling's Ford, on Schuylkill, are taking measures to erect one this summer at that place near 200 feet span, without any pier.

The following particulars it is thought will enable any person to make a rough estimate for any particular case. A bridge of 300 feet span and 30 feet wide, with two or more passages, so arranged that one may undergo repairs while the others are in use. To support such a bridge with four chains of inch and half square bar, would require about twenty tons of iron, and would be equal in strength to eighteen bars of iron one inch square—a strength capable of bearing 540 tons weight. And supposing the timbers to be of pine or other light wood, the whole materials will not amount to 140 tons; consequently the bridge will have an excess of power of at least 400 tons beyond its own weight.

A bridge of the same span fifteen feet wide would be supported by two such chains.

One of 150 feet span and 15 feet wide, would require about five tons of iron—the chains being one half the length of those in the first case stated, and the materials only one fourth of the weight. But in order to possess that strength on which these calculations are made, the chains must be allowed a sinking or curvature of nearly one sixth of the span; and when this proportion is adhered to, the strength will be the same, whether extended to three feet, or to three hundred.

When there is but one space or span, and no middle piers, nearly half the chains are taken up in fastening; but the same fastening would serve for any number of spaces.

The smith's work will cost two or three cents per pound, and the carpenter's work is not worth naming.

The scantling will cost about as much as the plank for flooring. No scaffolding is necessary for raising the bridge.

With allowance for thickness at the ends of the links, and wasteage in making, &c. a chain of inch and half square bar will weigh sixteen pounds per foot—one of inch bar will be about seven and a half pounds per foot. About one fifteenth of the span will give curve sufficient, and one fifth the weight of the chains will be iron sufficient for suspenders, bolts and keys.

An estimate on these principles for a bridge of 500 feet between the abutments, with only one pier, will not amount to seven thousand dollars, exclusive of abutments and pier. Compare this with the Philadelphia Schuylkill bridge of the same extent, which cost sixty-five thousand dollars after the abutments and the *two* piers were completed; total expense, three hundred thousand dollars.

It is believed that saving the expense of one pier, the duration of materials, facility of erection, as well as repairing, is worthy of public attention.

There is no reasonable doubt, that in some extraordinary case this kind of bridge will be extended to one thousand feet, when the subject shall be fully understood; and should it ever be necessary, I would undertake to satisfy any person concerned, that it is capable of a still greater extension.

As the bridge has no support but the chains, two things ought to be accurately understood; i. e. how much iron can bear at a direct pull endwise, and what it can bear in the other positions in which it is to be employed. As to the first, my experiments agree with the opinions of those who have investigated the subject; but I have made my calculations at 60,000 lbs. to the inch square bar, which is something less than the strength of iron of the lowest quality.

But what a chain will bear when the two ends are fastened, and the weight affixed to the middle, or rather equally distributed along it, is a question that I presume may be determined by fastening one end of a line, and extending the other horizontally over a pully:

whirl with a given weight attached to it, (say 10 lbs.) then let as many pounds be placed along the middle part at distances horizontally equal. The middle part of the line will then represent the chains loaded as when supporting the bridge. The end that hangs in the manner of a plummet, determines the tension, and the pully-whirl equalizes it between the two parts. The conclusion is unavoidable, that a line or chain will bear just as much with the curve of the middle part, as it would bear attached like a plummet; and this will be found equally true in a long distance as in a short one; so unequivocally true is it that the balance at the end determines the tension—that the line was as tense before any weight was put on the middle part, as when the ten pounds were affixed to it. The same ten pounds will balance fifteeen or eighteen pounds, provided the line is permitted to sink until the balances find their proper level or equipoise. It is also clear, that when there is little or no curve, *one pound* creates more tension than *ten*, when the curve is greatly larger. I have stated the strength of the chain at 60,000 lbs. per inch bar, when the sinking or curve is nearly one sixth of the span. By some hasty experiments that I have made, it appears that with a sinking of one ninth, it will bear 45,000 lbs. and at a sinking of one fourteenth, it will bear 30,000 lbs. and at a sinking of one thirtieth, it will bear only 15,000. Thus we see the effects of greater or less curve. Another purpose to be answered by the line and balances, is to find what position the chain would naturally take when supporting a bridge. We know it forms no part of a true circle, nor what is called the catenarian curve; the latter is formed by the weights being equal along the curve line, but in the case of a bridge, the weights are equal along the horizontal line.

EXAMPLE.

To find the proportions of the several parts of a bridge of one hundred and fifty feet span, set off on a board fence or partition one hundred and fifty inches for the length of the bridge, draw a horizontal line between these two points representing the underside of the lowest tier of joists—on this line mark off the spaces for the number of joists intended in the lower tier, and raise perpendiculars from each, and from the two extreme points, then fasten the ends of a strong thread at these two perpendiculars, twenty-three inches and one quarter above the horizontal line—the thread must be so slack that when loaded, the middle of it will sink to the horizontal line; then attach equal weights to the thread at each of the perpendiculars—and mark carefully where the line intersects each of them. The distances between those marks on the curve line, is the length of each link for its respective place; and the distances from each of these marks to the horizontal line is the length of each suspender for its proper place.

It will sometimes be convenient to have a pier so nigh the abutment, that a part of the bridge can be attached to the chain as it descends to the ground to fasten. In one case, where the elevation of the chain at the pier is but twenty feet, there is forty feet attached to the chain, and ten more to reach the abutment. In all these cases, the line and balances determine every thing.

In a bridge of but one arch or space, it must be considered a grievance, that the chains, including the branches, must be nearly twice as long as the bridge. I have just been trying on a space of 400 feet between two piers how much of the bridge can be attached to the chain as it descends to the bank to fasten; and it appears that about 170 feet may be attached to each end in this way. The two ends will and must be exactly in the position of a half bridge as far as they go, the end of the chain taking nearly a horizontal direction, may be let into the bank as far as may be thought proper. Here then is a bridge of say 740 feet, with scarcely any mason work but two piers, and the chains very little longer than the bridge. Suppose a shorter space to be divided in this way, say 300 feet, the middle space would be about 175: the chains would then need to be but a little more than half as strong, and not much more than half as long.

The spaces or spans may be different in the same bridge, and the suspenders must be longer in the short spaces, for although with equal weight on all the spaces the curve would be in proportion to the span. But the large spaces having more weight of bridge to support, must have more than its proportion of curve and the short spaces less, in order that the tension may be equal on all the spaces.

In a bridge of two or more spaces or spans a load on one will tend to sink it and raise the rest; to resist this tendency the framing must be bound down to the stone work; for this purpose let four pieces of iron for each pier be made long enough to reach quite through the pier, and with strong eyes at each end turned up some inches, let two of these pieces be built in each end of the pier, say ten feet down in the stone work, so that the eyes may barely appear on the face of the work, and one brace of the framing can be fastened down to each eye.

If there should be a large space and a number of lesser ones, or should it be necessary to raise the chain at a draw-gate, lay off your plan on some convenient scale as before directed, employ the line and balances, fixing whirls at every bearing, to equalize the tension. In this way the position of the chain will be ascertained at every place, and likewise the length of the suspenders for their respective places; and I venture to say that this plan and this only, of ascertaining the proportions, can be safely depended on.

It is a matter worth knowing, what is the tension of the branches, compared with that of the main chain. It is evident if there were only two branches, and they should open so as to form an angle of 120 degrees, (that is one third of the circle) each of the branches would then be equally tense with the main chain; but whatever angle the branches form in spreading to receive the stones, the tension can be ascertained by the line and balances.

It may be inquired whether all parts of the chain are equally tense when supporting the bridge? I answer that the tension is about an eleventh less at the middle of the bridge than at the ends. I have ascertained this by taking a line to represent the chain that supports one half the bridge only, and extending it over two pully-whirls, one at the centre of the bridge and the other at the corner where the chain is supported, and loading it horizontally equal as in the case of a bridge. It is evident that the weight at the upper whirl must be greater than that at the lower; and the difference between the two, shows the difference of tension between the middle of the bridge and the two ends.

The spreading of the branches, unless very considerable, increases the tension less than I could have thought. In the length of branches that I have proposed the increase of tension is not worth notice. I have just been trying with a small line and balances, the longest branches two feet three inches, and the shortest fourteen and a half inches, spread to fourteen and a half, and in that case the whole increase of tension in all the branches, appeared to be only one-seventh more than if they had all drawn in a straight line with the main chain. By these experiments it is probable that many of those concerned will be relieved from groundless fears. I have found great difficulty in obtaining permission to let the ends of the chains open each a foot or two off the direct line, so as to make the passage to and from the bridge more free, and remove the chains out of danger.

I know the young mathematician, with mind half matured, would smile at my mode of testing the relative force and effect of the several ties and bracings of any piece of framing: but the well informed, will not so lightly treat any information obtained or supposed to be obtained by actual experiment. If the process is before him, he will carefully ponder all the parts, and discover where the defect lies before he rejects the conclusions drawn therefrom.

SHAPE OF THE LINK.

It is plain that the bars in the middle of the link draw in a direct line, and it is easy to tell the strength: but is impossible to get the links fitted into each other as close and full as could be wished; to remedy which and to be secure in this point, it will be necessary to have those parts of the link made considerably larger. To accomplish this, nine or ten inches of each end of each bar is left a quarter of an inch larger than the rest, and two such bars make one link. As there is but one link of the chain to each space between the joists, there will not be much iron expended in this way. It is thought best not to round the inside of the links at the ends where they sit in each other, as there is no friction in the chain when in use. Every link will be so wide, that the side of the next one can turn freely in it, and the other side turn round its end, for the workmen will find it convenient to hang up the last made link of the chain, so that the lower end of it may be nearly on a level with the fire and anvil. In this way he will be able to turn up three sides of the one he is closing in, and will find no difficulty in shaping the work to his mind. This wideness of the link must always be filled up with the thickness of the end of the next. A link of inch and half bar will require to be more than two inches and a half wide, and the end where it is welded must be left just as thick, measuring through the inside of the link; but the outside of the end of the link, may be reduced to one inch and a half; this will give pliancy to the chain. Some have thought that in calculating the strength of the chain, we should not reckon on both sides of the link, because it is single where it passes through the end of the other link. This is a misapprehension: but nothing is more necessary than that this part should be well fortified. Let the quantity of iron in this place be two or three times as much as in any other part of the link.

Although I have taken considerable pains to ascertain and to demonstrate the strength of the chains, it must not be forgot that they may be overloaded. Some books when stating the strength of metals, advise not to load more than half, for fear of the injury by a continued tension. There are two other considerations that must be attended to—the corrosion at least of some of the parts, and we must not expect the execution of the work as complete as the mind could conceive it. And here I would earnestly recommend all those concerned, to adopt it for a maxim, that the chains in all cases shall be able to support five or six times the weight of the bridge.

It will be prudent in all cases to have the joists and plank as light as can be with safety. In cases where the bridge is twelve or fifteen feet wide, I have put the joists of the lower tier ten feet asunder, they being about ten inches by five in size. Each joist of the upper tier being one continued joist from end to end of the bridge, each space will bear double what it could were the joists cut into separate pieces for each particular space. Why? Because a joist just long enough to rest on bearings at the ends, can give way under its load by breaking in the middle only; but where it is one continued piece over many bearings, and all loaded, it cannot give way without breaking at both ends and middle. Besides, the whole system is of a yielding texture, much in the nature of network; but they had best be at least one foot deep, and not more than three inches thick in order to stiffen the bridge as much as possible, where the ends pass each other and are bolted will give them thickness enough to stand firm. Plank of two and a half inches thick have always been used, so far as I know.

In regard to the anchoring or fastening of the ends of the chains, there is much diversity of opinion. Many are highly pleased with the idea of fastening to a rock, when the situation will admit—some by letting the end of the chain into the rock with a staple or bolt to fix it to—and others by letting bolts into the rock with the head projecting out for a large piece of iron to rest against. To this large piece of (perhaps cast) iron, the chain is fastened.

This is wandering from our favourite principles. In those methods, the stiffness of the iron is depended on; and suppose the iron fastened in with lead, and the tension so great as nearly to tear the iron to pieces, will not the lead spue out like water? To my mind, all these methods have something in them too precarious and unsafe to be depended on. Give me a sufficient hold of a platform of some kind, and let me know the weight of the materials that rest on it, and I shall know on what I depend. And it must also be known in every case what the weight of the bridge is, and the fastening at each end must be, say one-third more. The fastening is no hard matter, and it ought to be remembered that a drove of cattle may sometimes get on at once.

The bottom of the digging to fasten the chains, had better be sunk say two feet deepest at the side next the bridge. This will give the platform a greater appearance of resisting the drawing of the chain. The shortest branches of the chain must be about eight feet long, and the other two will be about twelve.

It is settled beyond all controversy, that wrapping with canvass and pitch will preserve iron time out of mind, even in sea water, and that good painting is as effectual in an open situation. It must be granted that if any tolerable degree of care is taken, it will be but a very small part of the iron that can receive much injury. But supposing the chain bridge should become a total wreck in five hundred years, what then is the relative value of the ruins of this compared with that of any other bridge? And in point of duration, how will the account stand between this and a wooden bridge, even when covered? Will it be less than ten to one? And when uncovered, will it be less than thirty?

The chain bridge is as favourable to navigation as any other. It is only necessary, as in every other case, to have a pier on each side of the passage. The chains having nothing to support at that place, will pass in a direct line from the top of the framing on one pier to that of the other, which it is thought will generally give room sufficient for vessels to pass under. I long for a case where a draw-bridge is wanted; I should undertake to devise means without any chain crossing above, and cheerfully take all the risk on myself.

Those engaged in such arduous undertakings, will generally pay some attention to the different modes of accomplishing the same purpose. In the Cyclopedia will be found the following notice of iron bridges: "Bridges of cast iron are much celebrated; in particular that at Coalbrookdale, Shropshire, England, span 100 feet six inches, iron 378 and a half tons. Also the Sunderland bridge over the river Wear, single arch 246 feet span, iron 266 tons, of which 46 are hammered iron. In the years 1795—6, an iron bridge was thrown over the river Teme, in Hartfordshire, England. Its parts were so slender and ill disposed, that no sooner was the centre taken away than the whole tumbled into the river."

In the first of these cases the one hundredth part of the iron would be more than sufficient for such a bridge. And in the second case, less than twenty tons would at a fair calculation, support a bridge of the same extent, that would bear more than four hundred tons burthen. And when these monstrous massess of iron are got together, their bridge is just as far from being completed as ours, when the chains are up and ready to receive the timber; for they too have the flooring to make after the iron is erected.

May I venture to glance at the grand, the majestic arch of solid stone, with any idea of contrast between it and our simple contrivance? Happy for me, utility, economy and despatch, are the ruling passions of the day, and will always take preference of expense, idle elegance and show, until the minds of men become contaminated with vanity or some worse passion.

I confess I have not yet obtained materials for a proper investigation of this subject, but for the present let one case suffice: the Monockasey bridge of about six hundred feet, is nearly completed by the Baltimore turnpike company; the lowest estimate of total expense to finish it, I am told is sixty thousand dollars. Just about one fourth would have answered the same purpose on our plan. I venture to pledge myself, that one third of the money shall erect such a bridge and keep it in repair forever.

Although hundreds of bridges of superior elegance and extent, have gone to ruin in a very short time after they were erected, we will not suppose it possible that any part of the Monockasey bridge should tumble to pieces like the other bridges built by the same company.

But in estimating the expense of a stone bridge, what allowances is to be made for all the mismanagements and misfortunes that so frequently befal them? Perhaps it would be too much to say, that they must build two before they can count one; and yet I fear it would be hard to point out one of bold construction, without a fracture, or other strong symptom of decay.

It is remarkable that in a science that has been maturing for thousands of years, and in which nothing is undertaken but by those who have been regularly brought up to the business, we should hear of so many misfortunes, and so much want of skill!

Upon the whole, will it not be allowed that the best material has been chosen, (iron) the strongest and cheapest metal in the world—and applied in that way in which it possesses an hundred fold more power than it does in other positions?

Let the attentive mind be turned for a moment to the four chains erected to support a bridge of three hundred feet—here is the whole skeleton or frame of the bridge, and the whole strength, and what is it? Five hundred and forty tons at the lowest calculation!

May I not with some degree of exultation ask, who ever thought of the skeleton of a bridge so light and so strong, so permanent, and so easily erected and repaired or renewed in such parts as may require it?

I would invite a correspondence with any person who may have it in view to undertake a business of this kind. It would be pleasing to me, and might be of use to compare notes on a subject of so much importance. It is a great misfortune to be too wise before we get acquainted with the subject. And further, any observations honestly intended to point out an error in any of the above statements, will be gratefully received and punctually attended to.

A Table, showing the strength of Iron.

	Pounds wt.
Cast Iron, at a direct pull endwise, or weight attached to an inch bar,	42,000

Bar Iron, do. do.	59,000
Ordinary,	68,000
Stirian,	75,000
Best Swedish and Russian,	84,000

Encyclopedia, vol 18, *page* 10.

In March 1808 I entered into an agreement with Mr. John Templeman, of Georgetown, Maryland, by which he was to receive one half of all the monies arising from what permits or patent rights he could dispose of for and during the term of five years. All contracts to be in my name, and the money payable only to my agent in the city of Washington, who should pay one moiety over to Mr. Templeman. But in delineating the principles of my bridge I spoke only of one arch or space, and it seems that Mr. Templeman took it into his head that I should go no further; accordingly soon after our agreement he took a patent for all continuations, but he has thought better of it since, for I have gone on to receive the perquisites for all the spaces, with his knowledge, and without any complaint from him on that head.

In the same article it is provided that the parties shall not grant permission to build bridges on this plan at less than one dollar per foot span, without any discrimination as to breadth.

But gentlemen have proceeded to build with design to pay when the work should be completed, and have always paid on demand.

TRAVELS IN FRANCE—FOR THE PORT FOLIO.

LETTER LXXV.

Newport, R. I. July 20, 1806.

The few short lines I wrote you from Newyork will have informed you of our safe arrival after a passage of between six and seven weeks, and of our intentions to proceed to this place, where we are once more settled for the summer, after an absence of nearly three years.

It is a portion of my life, which, notwithstanding some moments of anxiety, I trust I shall always look back to with satisfaction; nor will you, my daughter, have been without your por-