1,000,000,000 cubic meters. Actual work upon the canal has been commenced at six points.

The contractors, Messrs. Slaven & Co., for dredging the canal from Colou, have their first herculean dredge in place, and will commence work directly. The Canal Company have been working with two French machines, at the rate of 1,000 cubic meters per day for each machine. The Franco-American Trading Co. have contracted for the excavation of about 10 kilometers of the canal beyond the Bay of Panama. Their machines are being built at Lockport. There are now about 6,500 men on the work, chiefly Jamaicans, Carthaginians, and a few Martiniquans.

Many dwelling houses, machine shops, etc., have been constructed. The machinery is both French and American, and the eleven American excavators are working with great economy. Borings have been made along the whole line, and have extended to the bottom of the canal, giving in a general way the following results: From Colon to kilometer 10, material easily dredged. From Mumei to Obispo, mostly clay, with occasional seams of rock. From Obispo to Emperador, about 7 kilometers of hard trap of conglomerates. From Emperador to Paraiso, about 8 kilometers clay for about 15 meters, then indurated clay followed by schist, and reaching rock near the bottom of the canal. From Paraiso to Pedro Miguel, 10 to 12 meters clay followed by rock. From Pedro Miguel to the sea, mostly clay and mud, with the exception of a few seams of rock.

Considerable work has been done at the port of Colon, including the commencement of a breakwater.

Much money has been spent in the purchase of materials for the work, including excavators, dredging machines, and portable track. The company has ordered 14 American locomotives, of which 9 are now in service.

Hospitals have been erected at Panama, and the health of the laborers is very much better than has been generally understood.

VIBRATIONS IN BRIDGES, ETC.

A MECHANICAL engineer of high repute—see SCIENTIFIC AMERICAN SUPPLEMENT, No. 381—quotes another engineer of equally high repute in fortifying the assumption that the counterbalances of locomotive driving wheels exert thrusts upon bridges or other supports, “downward when the counterweight is down, and upward when the counterweight is up.” And again, “as the wheel revolves, the centrifugal force acts in the direction of a radius through the counterweight.” Long and labored calculations are made upon this

false premise. The force of the imagined impact is even given in pounds, and a formidable array of equational figures is marshaled into position to make an error appear respectable. In his hurry he failed to see that the counterweight is but a component of a rotating mass, and not free to obey the impulses of a revolving body. An article in No. 368, SCIENTIFIC AMERICAN SUPPLEMENT, describes the conduct of his driving wheels.

Another writer, contributing to a journal entitled *Mechanics*, follows in the wake, without chart or observation, and his log reads: “A counterbalance is a poise so placed in the revolving parts of the engine that its centrifugal force at the two extreme points of the stroke shall be equal to the momentum of the reciprocating parts. Now, if we frame an equation, giving the centrifugal force of the poise, and place this equal to the inertia of the reciprocating parts reduced to the driving point, we shall then be in a position, knowing the weight of the reciprocating parts, to determine exactly what weight is required to counterbalance the engine.” Then he proceeds to “frame,” and a column of algebraic formulæ is reared upon the above imaginary foundation, topped out with, “These simple formulæ will be found to give satisfaction in every instance, and present no difficulties in their practical application.”

It is in no captious spirit that these errors are cited and met; but they are not entitled to the dignity of an analysis. The premises of the calculations being wrong, the conclusions must be erroneous. The reciprocating parts of an engine cannot in any degree be balanced by a counterweight in a rotating part. If F be of greater weight than the sum of G and E , there will be a striving of the journal to run in the path indicated by the dotted circle, I ; and instead of mitigating the shock of A , B , C , and D at the end of their stroke, it will aggravate it. Every rotating body will strive to rotate upon its center of gravity. F is a component of the mass K , not an independent particle. All that can be done with the parts A , B , C , and D in balancing them is to receive their shock upon a cushion of steam or other spring; in fact, all can be done in that way that is desired, for, if the cushion be as good as can easily be obtained, there will be no more shock than accompanies a pendulum, whose cushion is the attraction of gravitation.

An engine crank or balance wheel should be perfectly balanced within itself and for itself only, unless it run at so low a rate of speed that it will not pass centers without assistance; in which case, of course, a shock from any cause need not be anticipated. In an unconstrained rotating body the point of greatest prominence, or point of greatest distance from the center of rotation, it is also the point of greatest deficiency of weight. If, therefore, in the disk crank K the weight F be greater than that of the sum of E and G , E will be thrown farther from the center than if in balance. The moon revolves around the earth, not the earth around the moon; and the earth and moon, like a crank, swing together; and they do not swing upon the center of the earth either. These gentlemen with their railway wheels, cranks, engines, and counterbalances are capable of better writing; but in their precipitate hurry to get into print, they forgot to do their thinking.

If it be desired that a rotating body run smoothly, without jarring its surroundings, its properties must be the same as those of a body rotating in space, having a mechanical center around which it is desired it shall rotate, and a mechanical plane in which it is desired it should continue. Its mechanical center must coincide with its center of gravity, or it will leave its mechanical center, upon which it is supposed to have been set in rotation, and assume a center nearer to the superabundant weight by which its equilibrium is destroyed. See SCIENTIFIC AMERICAN SUPPLEMENT, Jan. 20, 1883. When the central forces of rotating

bodies exceed in energy the force of gravitation, the balancing of parts must be considered as referring entirely to rotating masses, and not to the components of the masses.

CHARLES SEYMOUR,
Supt. Defiance Machine Works.

THE MONONGAHELA SUSPENSION BRIDGE AT PITTSBURGH, PA.*

By Col. S. M. WICKERSHAM.

IN order to a proper conception of construction of thirty-eight years ago, in which time more than a generation of men have come and gone, it might be well to look into the then existing state of affairs bearing on the subject, and try to understand the difficulties which the engineer had to encounter considered in respect to the resources at his command with which to meet them. At that time work in the shop was done principally by hand. The slide rest was a novelty, and the straight edge and steady eye and hand turned out the piston rod. Screws were still cut in the lathe by hand. The whip saw was used to cut the floor beams of the aqueduct, in 1844. The trip hammer was still doing its noisy work, afterward so effectually silenced by the squeezer. The canal boat controlled the freight traffic between West and East, and steel was almost among the precious metals. But it would occupy too much time to go into this interesting part of the subject. We will therefore ask your kind attention to a simple narrative of events preceding and leading to the construction of the Monongahela bridge, and to an account of the method pursued in its building. I regret much being disappointed in obtaining some drawings which would have added interest to the description, so must do without them.

Up to the beginning of 1845, the bridges throughout this country were built of wood, wood and iron combined, or of stone, a few of chain—all generally of short spans, wood

wooden bridge built in 1818, by Lewis Wernwag, which was well known as being the longest single span wooden bridge in the world—343 feet between the abutments. It had succumbed to fire, the almost universal fate of wooden bridges.

There was no element of stiffness in the Fairmount suspension bridge, and it was subject to great vibrations. It was very graceful and pretty to the eye, but very unsteady to the feet.

This method of construction had been severely criticised by Mr. John A. Roebling, and a controversy had arisen between these distinguished engineers, Mr. Roebling maintaining that suspension bridges could be built possessing elements of stiffness and rigidity by a proper combination of its own elements; that by laying the wires in cables of larger diameters, the stiffness of a solid bar could be obtained. Mr. Ellet held it to be impracticable to combine the wires into a cable of large diameter so that each wire would bear its proper share of the burden, and that therefore the wires must be laid in cables of small diameter, adding to their number as additional strength was required. So the contest rested until 1844, when Mr. Roebling contracted with the city of Pittsburgh to rebuild the aqueduct across the Allegheny River, connecting the Pennsylvania Canal with the basins within the city, which enabled him to introduce the plan of suspension bridges he had so contended for.

There were 7 spans in this work; there were 2 continuous cables made of No. 10 wire B. G., each 1,175 feet in length from anchorage to anchorage, 7 inches in diameter, formed of 1,900 wires each, gathered into a round cable, and tightly and closely wrapped throughout with No. 14 annealed wire. The cable passed over stone pyramids on each pier and on the abutments, resting there on rollers. The suspension rods passing over the cables descended between the floor beams, which were put up in pairs, and block and washer below. The trunk was so made of two courses of $2\frac{1}{2}$ -inch plank, crossing each other diagonally and held together by

Span, 24 Meters. Width, 5 M. Height above water level, $76\frac{1}{2}$ M.

THE ALBULA BRIDGE, SOLIS, SWITZERLAND.

being the principal material used. The bridges were generally for highways, for foot and wagon traffic. Although about fifteen years had passed since the introduction of railroads, they had as yet not been extended very far. It was in 1845 a company was formed to build a railroad from Harrisburg to Pittsburgh. It was in 1845 a company was formed to build a telegraph line from Philadelphia to Pittsburgh. Here commenced the era of railroads which from its necessities produced the present era of iron and steel bridges.

At Philadelphia, Pa., a wire suspension bridge had been erected spanning the Schuylkill River, at Fairmount, at the expense of the county, by Chas. Ellet, Jr., C. E., who furnished the plan and contracted for the work at \$50,000. The abutments and columns were of granite, the distance between abutments 343 feet, between the supporting rollers on top of the columns 357 feet, width of floor and foot way 27 feet. The wire was laid in 10 cables, 5 on each side of the bridge—each cable extending from anchorage to anchorage over the top of the columns, and were fastened at the ends around numerous stout iron bars transversely embedded in the solid rock or in an immense body of masonry; this formed the anchorage.

Each cable was composed of 260 No. 10 wires, forming a strand $2\frac{1}{2}$ inches in diameter, weighing each 4 tons, and each being 650 feet in length. They were wrapped at short intervals with bands of wire. The cables lay in a horizontal plane; across the 5 cables iron bars were laid, to which were attached the suspending rods, which were composed of small wires aggregating an inch in area, which, hanging vertically, as did also the cables, were attached to the beams that supported the floor. This bridge was opened for travel in the spring of 1842. It was erected on the site of the

the side post and framing, as to be self-sustaining, so that the cables had really only to carry the weight of the water within it.

The total weight of the water in each of the seven spans, when the canal was full, was 295 tons; weight of one span, including all, 420 tons; average ultimate strength of each wire, 1,100 pounds; tension of one wire, 206 pounds.

Thus, for the first time, did Mr. Roebling introduce his system. But it was objected that the load in the aqueduct might be considered as constant, and the excess of strength was so great that many inequalities might exist and not become manifest for a long time, owing to the entire absence of vibrations, and therefore it was not a solution of the point at issue.

The work on the aqueduct was drawing to a close; it was opened for navigation on the 22d of May. When, on the 10th of April, 1845, the bridge over the Monongahela River, at the foot of Smithfield Street, Pittsburgh, which had been erected in 1818 by J. H. Johnson, after designs of Lewis Wernwag, was destroyed in the fire which, on that day, swept over the city, leaving 40 acres of ruins where in the morning had stood the principal portion of Pittsburgh's business houses, the blow was stunning, and for a time it seemed that it would be fatal to our prosperity. But soon the native energy asserted itself, and the work of restoration commenced.

The bridge company felt the necessity of re-establishing communication with the South Side, but were in no condition to incur any heavy expense. Every one seemed to be ruined, and it was questionable whether the needed funds could be raised; the cost of erecting the bridge was an important consideration.

Mr. Roebling seized the occasion to make and offer a plan and estimate for a wire suspension bridge, in which the abutments and seven dilapidated piers of the burnt

* Paper read before the Engineers' Society of Western Pennsylvania, May 14, 1883.

bridge could be utilized, and having all the mechanical appliances required in the execution of the work together with the skilled and unskilled workmen still with him at the aqueduct, determined not to miss the opportunity of introducing his distinctive method of construction to the world; he therefore made his estimates at a figure just sufficient to cover actual cost, leaving to future works his proper remuneration, and in this the near future richly proved his wisdom. The offer of construction was so low that the bridge company accepted it, and twenty days after the destruction of the old bridge, namely, on May 1, work of preparing for the new was commenced.

The abutments and piers of the old bridge had been greatly damaged by fire; the injured portions were taken down, and they were thoroughly grouted before the new masonry was laid.

The piers were 50 feet in length at bottom, 36 feet high, 11 feet wide at top, battering one inch to the foot. Two bodies of substantial cutstone masonry, measuring nine feet square and three feet high, were erected on each pier at a distance of 18 ft. apart. On these the bed plates were laid down for the support of the cast-iron towers, to which the cables were suspended by means of pendulums, each span being supported by two separate cables—there being in the whole bridge sixteen cables. Anchor rods for the towers were properly placed and walled in the masonry, anchor pits were dug within the abutments to a proper depth, a plank box made and placed on the bottom filled with cement grout, then the anchor plates with the first links were let down into the cement, a floor of double planking laid on top of the plates, and the masonry commenced and carried up, the spaces around the links being grouted with cement as the work progressed. On the curve the knuckles rested on cut stone; thus all the links composing the anchor chains were built solidly in the mass of stone until they reached the surface. Emerging from the masonry, they extended a distance of 45 ft. to the top of the towers on the abutment, where they were attached to the pendulums and formed the connection with the cables. They were carried up from the anchor plates on such a line as to throw the strain which they were to resist inside the foot of the abutments, insuring the stability of the structure so far as the ends were concerned.

The towers were composed of four columns connected by four lattice panels secured by screw bolts. The panels up and down stream closed the whole side of the tower, but those in the direction of the bridge formed an open doorway which served for the continuation of sidewalks from one span to another.

On top of the columns a massive casting rested which supported the pendulums to which the cables were attached; the upper pin of the pendulums lay in a seat which was formed by the sides and ribs of a square box occupying the center of the casting. For the purpose of throwing the whole pressure upon the four columns underneath, twelve segments of arches butted against the center box and rested with the other end upon the four corners.

The pendulums were composed of four solid bars of two feet six inches from center to center of pin, 4x1 inches, with heads of eight inches diameter; pin holes three inches diameter. To the lower pin, the cable of one span was attached directly, and the connection formed with the next cable by means of four links three feet six inches long and 4x1½ inches section. I may here quote the language of Washington A. Roebling, the distinguished son of John A. Roebling, "that the peculiar features of this bridge were the pendulums, as by means of these any concentrated load upon one span was distributed over all the others, from anchorage to anchorage. By means of these it became possible to use the small towers which were built upon the narrow piers of the old bridge."

While adopting the pendulums for this bridge, Mr. John A. Roebling did not recommend their general use. In consequence of the pendulum system, several times during the existence of the bridge our rivermen were enabled to pass under with their boats, whereas without it they would have had to await the fall of the river; in cases where they lacked up to nine inches of headway in the channel span, they would have all wagons stopped in the two contiguous spans, thereby depressing them and raising the channel span so as to let them through, and this was often of great importance to them.* Before the completion of the piers and abutments, an earnest effort was made by Mr. Roebling to be allowed to raise the level of the bridge ten feet—the expense of which was estimated at \$10,000—but without avail; quite a bitter controversy arose on the subject. The up-river interests called for its raising. Here it was urged that giving a greater headway over the channel might enable boats to ascend direct to Brownsville, making Pittsburgh but a way station between the West and the East. In those days Brownsville was the point where the National Road—one of the main arteries of Western travel—struck the Western waters. From thence handsome packets brought the traveler to Pittsburgh, and this travel formed an important item in our resources, as the passengers generally laid over at least one night in Pittsburgh before taking steamers for their Western homes, this delay furnishing opportunity for our merchants and manufacturers to secure many good customers; and the general feeling was averse to doing anything that might impair this advantage, and move the head of navigation to Brownsville.

In June, 1845, the Brownsville *Herald* charged the Hon. William Wilkins, then president of the Bridge Company, as successfully opposing the rebuilding of the bridge at an increased height on the ground that it would let boats pass up to Brownsville to the injury of Pittsburgh. Mr. Neville B. Craig, then the able editor of the *Pittsburgh Gazette*, in reply said that he doubted the correctness of the report, and denied that the rebuilding of the bridge at the old grade or a higher one would have any effect on the business of Pittsburgh, adding: "This is sheer folly. Pittsburgh, from her size and wealth, her geographical position, her situation at the terminus of the Pennsylvania Canal, and as the converging point of roads and trade, and means of intercourse with a wide extent of country, is eminently a point for commencing and closing voyages. In this respect no other places on the Western waters equal her, except St. Louis and New Orleans. How preposterous then to suppose that the raising or lowering of a bridge is going to affect her trade. We would be glad to see the bridge raised to give our Brownsville neighbors the fullest opportunity of rivaling Pittsburgh."

Again, on the 26th of June, Mr. Craig expressed the wish that the bridge might be raised to the level of Smithfield Street. But the reason given for not raising the height of the bridge, and which we may receive as the correct one, was the low condition of the finances, the gloomy existing state of affairs generally, and the fear of getting into trouble

by saddling themselves with an additional debt of \$10,000, at that time, and all circumstances considered, a fearful amount. The construction of the bridge was therefore continued on the original plan without alteration.

While the work was progressing on the abutments and piers, the wire for the cables was being made. There were at that time but two wire factories existing west of the mountains, Townsend & Co., at New Brighton, Pa., which establishment is still in existence and noted for the excellent quality of its product, and the Pittsburgh Wire Works, Samuel M. Wickersham, which works were swept out of existence by fire, in 1850, and never rebuilt. To these two works was given the contract to make the wire for the cables, and about equal quantities were made by each. The greater portion of the iron used in the manufacture of the wire was made and rolled into one-quarter-inch rods, by Lyon, Shorb & Co., of Sligo Iron Works, and it is well to mention here as showing the advance in thirty-eight years in the manufacture of iron, that the rods then furnished generally weighed but 8½ pounds, though some were rolled of 11 pounds weight, and, when they came from the rolls, were so chilled as often to be blue, and always requiring to be annealed before giving them the first break down, and then a second annealing and scouring before finishing to No. 10 for the cable. The wire was finished hard and bright. Now it is possible to have rods of steel of 100 pounds weight, and finished so soft as to admit of being drawn into wire of same number with the proper hardness and ductility and strength with but one annealing.

The wire for wrapping the cable was drawn to No. 14, and finished by annealing. The anchor and pendulum bars were made by W. H. Everson himself, in a small forge consisting of a not very heavy helve hammer and heating furnace, where he could be daily seen with his leathern apron on, handling the tongs, a prototype of Pat. Lyon, at the very spot on which now stands one of the great iron works of Pittsburgh, and at the head of which Mr. Everson still remains.

The Pennsylvania Iron Works is the thirty-eight years' growth of the modest Pennsylvania Forge.

Mr. Everson made the plates out of Juniata blooms—they were required to be of 65,000 pounds tensile strength per square inch—the fact was they were made of what was considered the best iron to be had, and Mr. Everson's knowledge of the quality was the real test the iron was subjected to. All the material used in the structure was closely examined and tested by Mr. Roebling by all the means then at hand—for well he knew that in so light a structure quality became of the greatest importance, and, so far as he could do so, he allowed nothing else to enter into it.

Each wire was tested to 1,200 pounds tensile strength; it was also held in a vise or in the pliers and bent to a right angle, then bent over to the same angle in the opposite direction, then straightened up; if it stood this without fracture, it was received, if not, it was rejected.

At this time the ground on the south side above the bridge site was in open fields; there the workshops were erected and the cables made. Two platforms were built of a height equal to the required deflection, at a distance apart equal to the length of the cables; an iron pin fixed on each platform on which a cast iron shoe was placed; a guide wire was stretched from pin to pin, giving the exact length and deflection of the cable. The cables were formed from a continuous wire; the short wires composing it being connected by tapering the ends for about 3 inches with a file, placing the scarfed sides together and wrapping the joint with a fine annealed wire; the wire was then taken from the reel and the bight carried by a wheel from one pin to the other. By means of a hand windlass and a pair of pliers to clutch it, each wire was drawn up to correspond with the guide wire in the center. When thus 750 wires were in their places, they were clamped and wrapped by the wrapping machine, worked by hand, from end to end with the No. 14 annealed wire into a compact round cable. When finished, by the aid of a large screw, the cable was drawn back, slipped from the pins, and laid upon the ground; the wires were each coated with boiled linseed oil and the cables well covered with white lead paint to prevent oxidation. When all the cables were completed, planks were laid upon the ground, and by means of rollers and fall blocks they were moved to the river side and placed on flat boats which had been coupled together end to end; the boats were then dropped to and anchored between the piers.

The towers being well guyed to avoid pulling them over, while the cables were being hoisted to their places, blocks were attached to their tops and the cables raised and connected to the pendulums. This part of the work was commenced in the second or third span from the Pittsburgh side, hanging both cables and working both ways until all were in position. Then commenced the laying of the floor beams; these were of white pine, 31 feet long 4½x15 inches, they were placed in pairs at a distance apart of 4 feet.

The suspension rods, made of one and one-half inch round charcoal iron, were attached to clamps which embraced the cables, and then passed between the floor timbers and through a bearing block and cast iron washer below. In hanging the beams care was taken that the spans should not be loaded too heavily at one place; so when seven or eight were hung on one side the span, the same number would be put on the other side, and thus alternately placing them, would finish each span in the center.

The floor was double, the first laid lengthwise of the bridge, the second across; the roadway was 20 feet in width, separated from the sidewalks by fender rails. The sidewalks were each 5 feet in width, elevated a few inches above the roadway, and were outside the cables. The total width between the railings was 32 feet. The railing was an open lattice of sufficient depth to be self-sustaining, and was one element in giving stiffness to the bridge. A curious circumstance, and worthy of record, occurred at several times to this railing; it was finished with a broad cap piece running lengthwise of the bridge, covering and concealing the ends of the plank forming the lattice work. Owing to the vibrations of the bridge, this cap piece would work somewhat loose and take a sliding motion, and several times the friction thus caused set the railing on fire. The movement was of slight extent, but so rapid as to produce this effect.

The opposite cables, as well as the pendulums, were inclined toward each other, the distance apart being 27 feet at the top of the towers and 22 feet at the center of the spans. The pendulums on the abutment occupied a vertical position.

The floor was further supported by a number of stays, made of one and one-quarter inch round charcoal iron, extending from the tops of the towers to the beams below for a considerable distance on each side of the piers. Timber supports also extended a short distance from each pier and each abutment; a wooden beam extended across the bridge from top to top of the towers, for the purpose of resisting the side tension of the cables.

As stated, the tearing down the portions of the old abutments and piers, which had been injured by the fire, was commenced on May 1, 1845. The new work was begun in June, continued without intermission through the summer and fall and following winter—a great portion of the work having to be done in the cold weather of the winter.

The bridge was thrown open to travel in February, 1846, eight months after its building began, and nine months after the contract for its erection was signed; but it had been used once before. On the night of December 31, 1845, the ice in the Monongahela River broke up, owing to a sudden rise. At noon of January 1, 1846, to relieve the great inconvenience, the first floor having been just laid, the passage of wagons was allowed for one hour, and with great trepidation did the worthy treasurer of the company, Mr. John Thaw, walk to and fro until the whole stream of market wagons and other vehicles, occupying at times the entire length of the bridge, as many as seven teams being on one span at one time, had passed safely over.

The whole cost of the bridge was \$55,000.

The masonry cost \$13,120
The superstructure cost 41,880

In all \$55,000

It is probable that no other bridge in the world, of same length, having a double carriage way and two sidewalks, has ever been constructed so cheaply.

The bridge is memorable as the first example of the solid wire cable, being in great measure depended on to give not only support to the bridge, but also resistance to oscillations. The combination of the wires composing it into one tightly-bound cylinder, while giving a strength of unerring certainty, also gives a stiffness almost equal to that of a solid iron bar, while by hanging the cables, with their planes inclining toward each other, a strong resistance is offered to lateral disturbances, and the almost solid inverted arch—which the cables themselves form—with their solid iron rods connecting to the floor offers the same resistance to vertical movements, thus providing against all the forces with which a bridge must battle. This surely entitles Mr. John A. Roebling, its architect and constructor, to a position in the front ranks of civil engineers.

In this bridge many small defects may have been developed in its thirty-seven years' use—some parts may have been made too light—if such have been developed in the taking of it down, it will probably be found that they were such as could have been replaced, as the bridge was so built that any part of it could have been got at and repaired if injured, or renewed if requisite.

The bridge was subject to no greater vibrations than are generally observed in the wooden arch and truss bridges of same span.

It has often been sorely tried, sometimes when crowded with people viewing a boat race, and sudden rushes would be made from one side of the bridge to the other. I have heard from Mr. Roebling that he thought it was tested to half its strength.

This bridge is memorable also as being the first of a series of which the last is the great Brooklyn Bridge, now approaching completion.

In addition to my own personal knowledge relative to the construction of this bridge, I wish to acknowledge my indebtedness for valuable information in the preparation of this paper to:

Washington A. Roebling, of Brooklyn, New York.
Jonathan Rhule, of Phillipsburg, Pa., for long time foreman for Mr. John A. Roebling.
Wm. M. Lyon, Esq., and Wm. H. Everson, of Pittsburgh, Pa.

The editors of the *Pittsburgh Gazette*, who kindly placed their old files at my disposal.

Reference was also had to:
Frederick Overman's work on Mechanics
Neville B. Craig's *Olden Time*.
Appleton's *Cyclopædia of Applied Mechanics*.
Day's *Historical Collections of Pennsylvania*.
And Mr. John A. Roebling's own report to the *New York Railroad Journal* in 1846.

TABLE OF DIMENSIONS OF THE MONONGAHELA SUSPENSION BRIDGE.

Length of bridge between abutments	feet	1,500
Number of spans		8
Length of each span	feet	188
Deflection of cables	"	14
Number of cables		2
Number of sections of cables		16
Diameter of cables	inches	4½
Number of wires in each cable		750
Weight per foot of each cable	pounds	39
Weight of cables and mapping		119,000
Length of the 16 cables	feet	3,036
Ultimate strength of the 2 cables		860
Aggregate weight of one span so far as supported by the cable with 100 head of cattle on it	tons	110
Tension of cable produced by dead load of bridge and 100 head of cattle on one span	tons	192
Weight of 100 head of cattle at 800 pounds	"	40
Tension resulting from it when at rest	"	70
Weight of four six-horse teams loaded with 104 bushels of coal each	tons	28
Tension resulting from it when at rest	"	49
Weight of superstructure of one span so far as supported by cables	tons	70
Tension of cables resulting from it	"	122
Section of anchor chains and connecting links	inches	36
Section of pendulums	"	32

THE LONGEST AND HIGHEST BRIDGES OF THE WORLD.—The longest viaduct in the world built of stone is that which connects Venice with the mainland. Its length is about two miles and a quarter. The longest iron bridges in the world are the following: Parkersburg Bridge, one mile and a third; St. Louis Bridge over the Missouri, about a mile and a quarter; the bridge over the Ohio at Louisville, about a mile; East River Bridge, New York; Delaware Bridge, Philadelphia; the Victoria Bridge at Montreal; the Volga Bridge at Sysran; and the Moerdyk Bridge in Holland; the five latter all being rather under a mile. The loftiest bridge is in France. It is the Garabit iron bridge in the department of Cantal, but will not be ready for opening till next year. It stands at such a height that the Vendome Column on the top of the Cathedral of Notre Dame could stand under it, its height above the valley being 406 feet. This is 72 feet higher than the Kinzua Viaduct in America.—*The Builder*.

* Since writing the above, I am informed that on one occasion Wm. Robinson, by means of heavily loaded coal teams, raised the channel span fourteen inches, and passed his boat under.