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RENEWAL OF NIAGARA SUSPENSION BRIDGE.

The re-enforcement of the anchorage and the renewal of the suspended superstructure of the Niagara Suspension Bridge, without a moment's interruption of traffic, rank as one of the most prominent feats of modern engineering; and the fact that, with a slight exception, the wires forming the cables and suspenders were found by the inspecting engineers unimpaired, is most significant and reassuring.

We have taken extracts from the report of Mr. Leffert L. Buck, engineer of the work, and give engravings from the engineer's drawings and from photographs furnished by Mr. William G. Swan, superintendent of the bridge.

From the inception of the project of spanning the chasm of the Niagara River below the falls with a suspension bridge for railroad purposes, to the year 1855, when the bridge was completed and opened to traffic, it was considered a bold undertaking, and by some engineers, even, as an impracticable one. But the bridge has been in constant use for twenty-five years, and under constantly increasing traffic, demonstrating the adaptability of a wire suspension bridge to a locality requiring extremely long spans.

In spite of its success, however, it has been an object of constant solicitude to the traveling public. The frightful chasm that it spans would naturally excite the fears of most people, and this feeling has been greatly enhanced by doubts as to the condition of the cables and their anchorage.

The bridge consisted of two pairs of iron wire cables and the suspended superstructure, the cables resting on masonry towers at each end of the bridge, their ends being secured by means of chains to suitable cast-iron anchor plates bedded in the rock forming the banks of the river.

The suspended superstructure consisted of two floors, placed at a vertical distance apart of 17 feet, and connected by posts and rods in such a manner as to form a trussed tube, as shown in Fig. 2. At each five feet in the length of the trusses, two wire rope suspenders connect the upper floor with the upper cables. In the same manner the lower floor is suspended to the lower cables.

Each cable is composed of seven strands or bundles of wire. Each strand is made up of 520 scant No. 9 wires laid parallel, and at each end formed into a loop which fits into a groove in a U-shaped cast iron shoe. The seven strands are bound into one bundle of 3,640 wires, which is served closely with wire over the whole length, with the exception of about 13 feet at each end, and of about 10 feet of the portions resting on the towers, thus forming a cylindrical cable 10⅛ inches in diameter.

The tops of the towers are each covered with a cast iron plate, 8 feet square, bedded in mortar. The upper surface of this plate is planed to a true surface and supports a number of turned rollers 5 inches in diameter. On these rollers rest the saddles, consisting of heavy castings whose undersides are planed. The top of each saddle has a groove of semicircular section in which the wires of the cable lie, each cable having a separate saddle. The planes of the curves of the cables, between the towers, are inclined in such a manner as to bring those of each pair nearer together at the middle of the span, to give lateral stability to the bridge. From the towers to the anchorage the cables diverge from the center line of the bridge sufficiently to make the plane containing the portion each side of the tower vertical. The wire forming the cables was boiled in linseed oil before it was laid, and as the cables were made the interstices at the shoes and towers were flushed with boiled linseed oil and Spanish brown paint. Then the whole length of the cable was flushed with the same as the serving progressed.

Each end of each cable had a separate anchorage, as shown in dotted lines in Fig. 3.

A rectangular pit or shaft, 3 ft. x 7 ft. in plan, was sunk vertically into the rock, to a depth of 25 feet, with the bottom enlarged to form a chamber 7 feet square. An anchor plate, 6 feet 6 inches square and having seven rectangular openings through it to receive the lower links of the anchor chain, is set in the chamber, the links put in position, and secured by a 3½ inch diameter pin passed through their heads and underneath the plate. From the plate the chain passes vertically upward to the surface of the rock. From this point the joints of the chain are at points of a vertical curve of 25 feet radius, the joint at the upper end of the curve forming the point of the tangency with the line of the cable.

Beyond this joint is another length of chain composed of nine links, each bar of which is 10 feet long and 7x1⅜ inches section. Four of these links alternate with the shoes of three of the strands of the cable, and are secured to them by a 3½ inch diameter pin passing through links and shoes. The remaining five links are in like manner connected with the remaining four shoes of the cable strands.

The anchor plates are secured in the chambers by means of neatly fitted stone blocks set in cement mortar, the whole pit being solidly filled with cement masonry, and the interstices around the bars grouted. Above the rock and up to the end of the chain the whole is inclosed in a solid wall of masonry, heavy blocks of which form supports of the joints of the curved portion of the chain. Formerly the strands were also covered with masonry and the whole grouted, the intention being to preserve them from corrosion.

Such, in brief, is the description of the cables and anchorages before the new work was begun.

The appearance of the old superstructure of wood, and wire suspenders and stay cables, is familiar to all who have seen the bridge, or pictures of it, and therefore need not be fully described in this connection.

In February, 1877, Mr. Thomas C. Clarke, Member Am. Soc. Civil Engineers, with a view to examining the condition of the portions of the cable strands embedded

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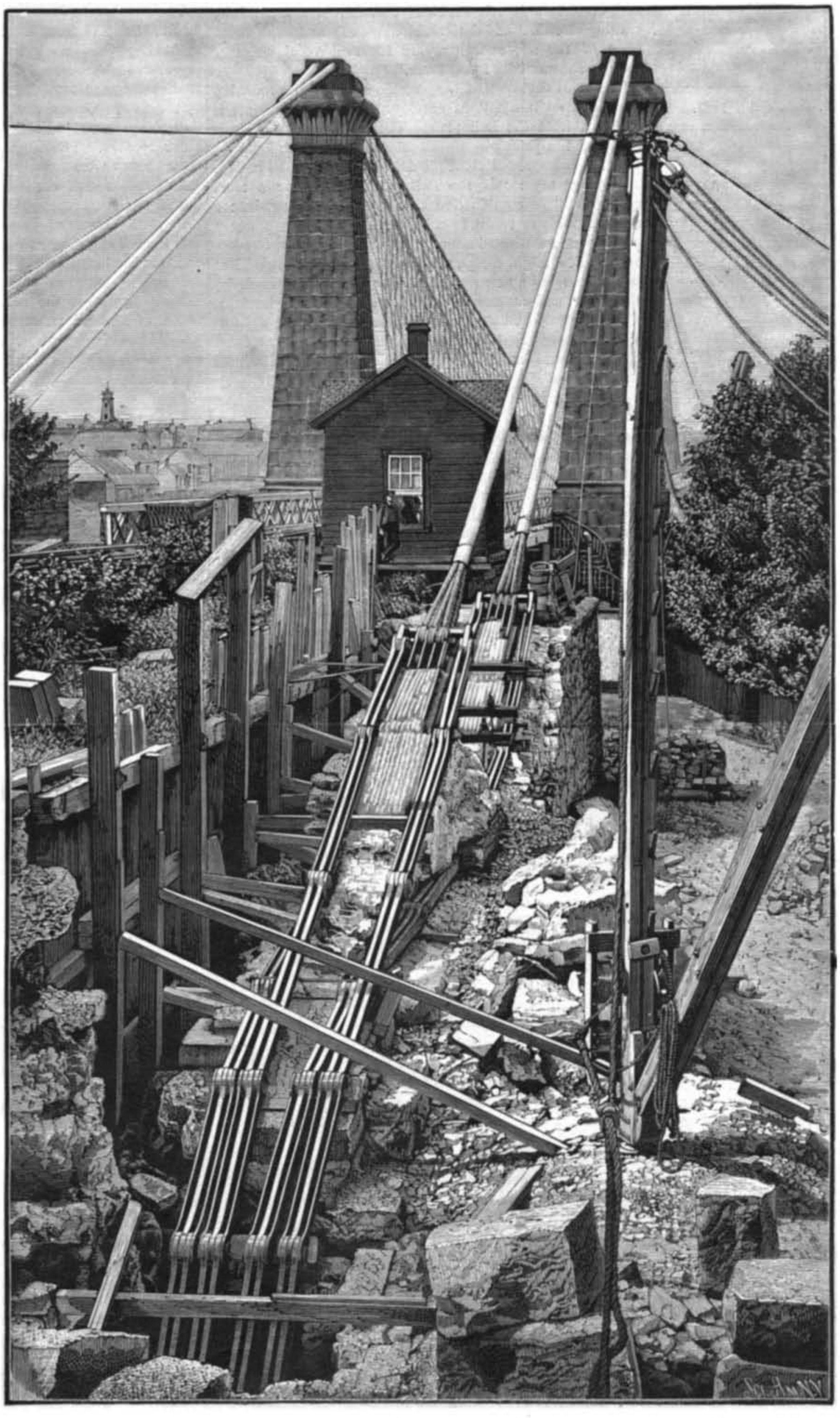

RENEWAL OF NIAGARA SUSPENSION BRIDGE—RE-ENFORCEMENT OF THE ANCHORAGE.

RENEWAL OF NIAGARA SUSPENSION BRIDGE.

[*Continued from first page.*]

in the masonry, caused a small excavation to be made near one of the shoes. On reaching the first strand, two or three of the wires were found to be corroded quite through and others were partially corroded. Shortly afterward Col. W. H. Paine, of the East River bridge, visited the bridge, and gave orders for the removal of all the masonry covering the strands of each cable. He also made tests of the elongation of the strand portion of one of the cables, by means of a Vernier scale. He found in this way that the elongation under a given moving load, on the bridge, was no greater than the modulus of the wires would allow, supposing the total section to be the same as when the cables were new. He also cut out some pieces of wire and tested them for tensile strength, ductility, etc. Their ultimate strength was fully equal to that of the new wire per unit of section, and their reduction of ruptured section was satisfactory, but as the wires tested were etched in places, of course the stretch would be principally confined to the etched portion, hence rendering any measurement of the stretch a matter of extreme difficulty.

In March, 1877, Mr. Buck joined Col. Paine at Suspension Bridge to assist in examining the condition of the bridge and in repairing the defective wires. After the strands were thoroughly cleaned and the wire bands removed, they were opened, the paint removed from the interstices, and the inner wires examined. They were found to be in as good condition as when first put in. The outer defective wires were cut away so as to uncover the second layer of wire at the bend of the shoe, when the second layer, or course, was found to be sound and bright. Thus it was found that the only wires affected were the outer wires of the outside strands. Near the cylindrical portion of the cables, the outer wires were slightly rusted clear around the cable, but as the shoes were approached, the etching appeared to work toward the lower

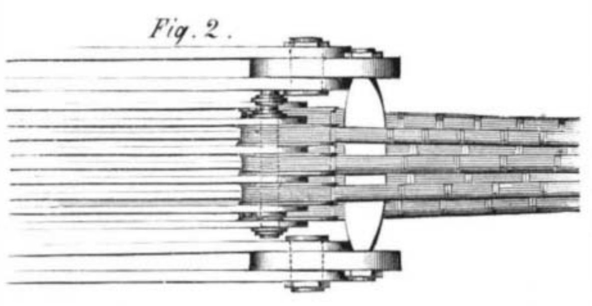

Fig. 4.—Plan showing connection of New Chains with the Cables.

strands, till, when the shoes were reached, the principal corrosion was of the outer wires underneath the bottom shoes. The evident cause of this corrosion was the elongation and contraction of the strands under the passing loads, which had loosened the cement from the outside strands, allowing moisture to work in and finally reach the lowest point. The portion of cement among the strands would go and come in a body with them.

While the examination was going on, the defective wires were cut out and new ones spliced in under strain. The greatest number of wires that required repairing at one end of any one cable was sixty-five, a number quite insignificant compared with the total number (3,640) comprising each cable.

This examination of the bridge resulted in the appointment by the bridge companies of a commission to examine the entire structure and to report upon its condition. After a very careful examination the commission reported that the repairs of wires, affected by rust, having been completed, the action of the wire portion of the cables indicated that they were in good condition. But regarding the anchor chains, it was believed that the strength of the bridge might be augmented by re-enforcing them.

The report was accompanied with plans for re-enforcement of the chains, and required that it should be made. The report also suggested the renewal of the suspended superstructure with iron, and submitted a general plan for that purpose prepared from data obtained from Mr. Roebling's published report on Niagara Suspension Bridge.

This plan was subject to such alterations as circumstances should require, and the engineer in charge accordingly made alterations which appeared to be necessary on getting to the surface of the rock.

In this plan the pits were located the same as in the other, but smaller. One anchor plate in each pit was made to answer for all the four chains. There were eight links secured in the plate by one pin, and the first joint, *c* (Fig. 3), was secured by one long pin. Beyond *c* each of the four chains was independent of the others, but had the same curvature and rested on the same stone supports. Two of the chains connected with the upper cables. The other two passed along grooves cut in each side of the wall, passing the supports of the old upper cable chains and fastened to the lower cable.

As will be seen by Fig. 3, the plan followed required a bend in the lower cable chain to bring it on to the line of the cable. This was done by dividing the change of direction among three points, and securing them in position by means of stirrups attached to the ends of the pins of the old chain, as shown at *a*, *b*, and *c*. In plan the pits are 6 ft. x 2 ft. 6 in. On the New York side they were sunk to a depth of 17 feet. On the Canada side to 23 feet. At the bottom the pits were chambered to 6 x 7 ft. in plan, for the reception of the anchor plates.

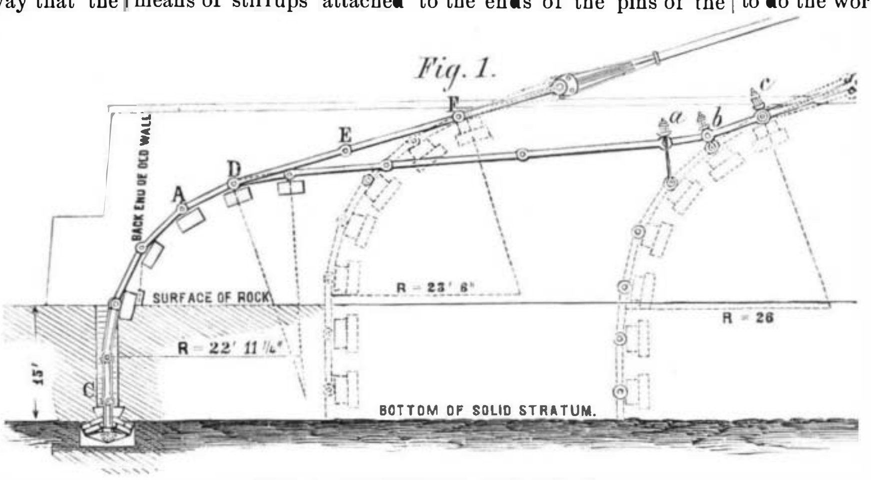

FIG. 3.—SECTION OF ANCHORAGE.

The anchor plates are of cast iron 5 ft. 6 in. square and strongly ribbed. Each plate has eight cavities cored into it for the reception of the lower heads of the links inclosing them perfectly. One pin passes through the whole eight links and all the partitions of the plate. After the plate was properly placed in the pit it was solidly concreted underneath. The stone blocks above the plate were cut to fit each place with thin joints, and the pieces as large as could be got into the chamber and notches. All vacant places were filled solidly with stone and cement, but no stone was permitted to come in contact with the chains.

After the new chains were adjusted the masonry was rebuilt and both new and old chains covered and grouted solidly, and the wire strands were covered with brick houses.

In renewing the suspended superstructure it was decided to use steel for the posts, chords, track stringers, and lateral rods, and iron for all other parts.

It was also decided to put the new iron beams in, nearly throughout, before commencing the work of erection proper. The work began at the middle and proceeded toward each end. When 150 feet of the new work was in place, the new chords were securely clamped to the old by means of oak and pine timber.

The portion of the new work thus put in place weighed about 1,100 lb. per running foot of bridge. Hence there were seldom over 90 tons of new material overlapping the old, but at the start, being in the middle, this was equivalent to about 150 tons distributed, or deducting the 80 tons, saved by stripping the bridge, there were 70 tons as the probable extra dead load upon it, but as the trains had at the outset been limited to 190 tons, it is not probable that the total weight of live and dead load ever exceeded that of ordinary usage.

While these changes were being made, the work of replacing the lower floor was going forward each way from the middle. After the work of replacing the trusses and floors was completed, that of renewing the track began at the middle and proceeded each way at the rate of 30 feet per day, or of 60 feet total. This could have been done without interrupting traffic, but as the Great Western Railway Company was to do the work of removing the old material of the track and put on the new timber, they preferred to take an hour each day, when there was no passenger train and scarcely any freight to cross, and make the change of 60 feet at one time.

The camber was made as nearly an arc of a circle as possible. The stress on the suspenders was adjusted by means of a hydraulic weighing machine.

In a suspension bridge of this sort, to make the overfloor stays (or those from the tops of the towers to different points of the floors) effective, a continuous iron truss is required, the middle point of whose length shall be as nearly stationary as possible. The trusses in this case are continuous from end to end. In order to keep the middle from moving toward either end the automatic device shown at the end of the lower chord (Fig. 5) was designed. In the prolongation of the line of the lower chord is an abutment casting, A, firmly secured to the masonry of the arch. This casting receives the end thrust of the chord. There is one of these castings at each end of each lower chord.

A bent lever, B, has its fulcrum, E, secured to A. At the end, D, of the short arm of the lever is hinged one end of a three-quarter inch diameter round rod, R. This rod extends through the lower chord to the opposite side of the river, where its other end is secured to the abutment casting

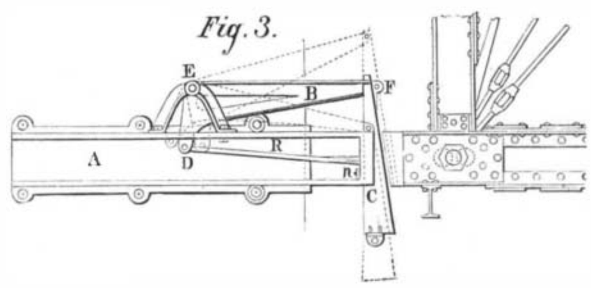

Fig. 5.—Automatic Truss Adjustment.

by a nut, *n*. At the end, F, of the long arm of B is suspended a cast iron wedge, C, which is interposed between the end of the chord and of the abutment casting. The action of the device is as follows:

The change in length of the chord, between extremes of temperature, is about 8½ inches. If the middle of the chord is stationary each end will consequently move 4¼ inches between extremes. The rod, R, which lies loosely in the chord, but otherwise is independent of it, is a little longer than the chord, and will change in length, between extremes, 8½ inches, or double the movement of either end of the chord. Hence the other end of the rod being fast, the end, D, will move 8½ inches, carrying the end of the lever with it at the same time that the end of the chord moves 4¼ inches. Arm, E F, of the lever is three times the length of D E, hence F will move 25½ inches, or six times as far as the end of the chord moves. Consequently the wedge, C, is made with an inclination 1 to 6 of its length. There is one of these wedges at each end of each lower chord. When the chord contracts the rod contracts in the same proportion and at the same time, thus bringing a thicker part of the wedge between the chord and abutment.

There is half an inch of space at each end for the chord to go and come in before bearing upon the wedge, an amount which is very nearly constant for all temperatures.

The long rods lying inside of the chord, they both keep at nearly the same temperature with each other.

The wedge has two surfaces of friction, and hence its inclination of 1 to 6 is far within the angle of friction of cast iron. Hence no matter what the pressure of the chord, it brings no stress upon rod, R, except what is required to sustain the weight of the wedge.

The weight of the old wooden structure, at its completion, was estimated by Mr. John A. Roebling at 1,000 tons. But at the date of the inspection, there having been a large amount of timber added to it, it was esti-

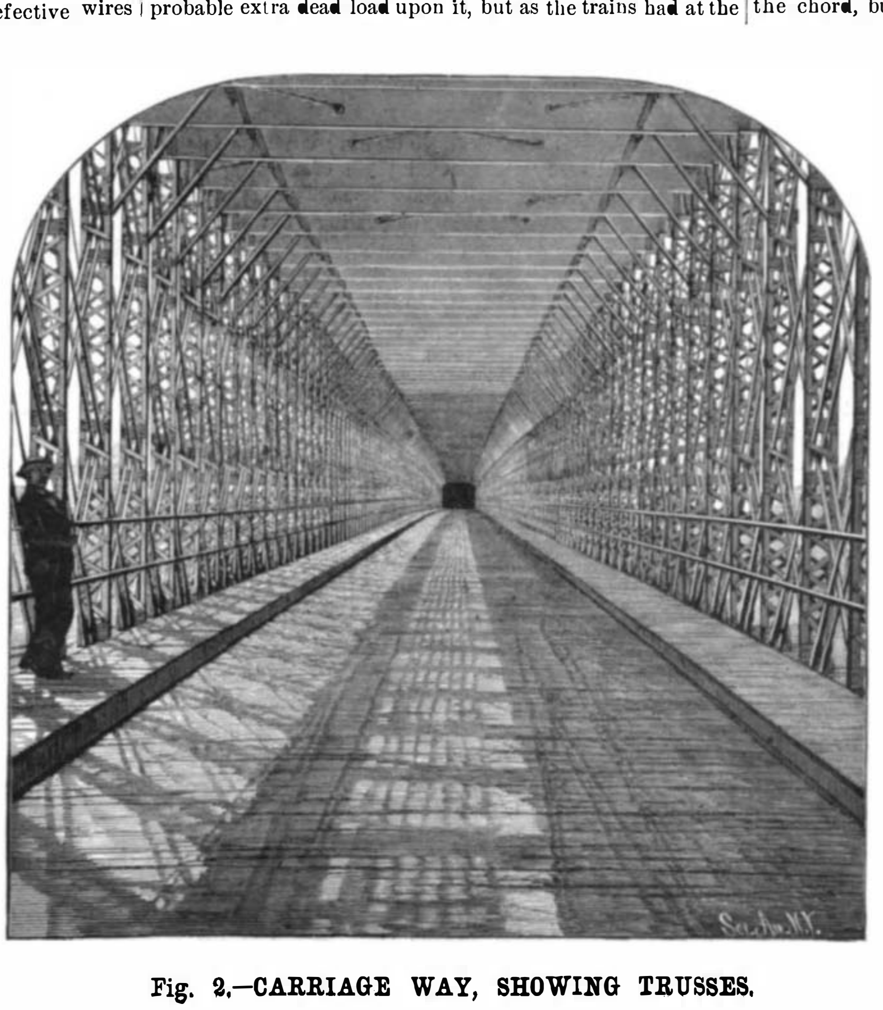

Fig. 2.—CARRIAGE WAY, SHOWING TRUSSES.

mated to weigh 1,130 tons. When the work of replacing the lower floor beams was in progress, Mr. Buck had one of them weighed, and found that owing to the amount of water that it held it was very much heavier than it had been estimated. He also weighed other pieces of the bridge, and from these made a new estimate, with the following result:

Total suspended weight between the towers: Old bridge, 1,228 tons; new bridge, 1,050 tons. Difference in favor of new bridge, 178 tons.

It is possible that the estimate of 1,228 tons is somewhat in excess. But as the new bridge is now higher in the middle than the old one for the same temperature, notwithstanding that the middle suspenders have been lengthened over 3 inches since its completion, that would indicate a decrease of considerably over 100 tons.

Cerebrology of Criminals.

A curious observation has been made by Dr. Moritz Benedict, of Vienna. He published a book about a year ago, "Anatomische Studien an Verbrechergehirnen," in which, among other notes, he states that in nearly one-half of the brains of persistent criminals the superior frontal convolution is not continuous, but is divided into four sub-convolutions, analogous to the disposition of the parts found in predatory, carnivorous animals. In a recent paper (*Centralblatt fur Med. Wiss.*, November 13, 1880), he argues that much of moral perversity may and must be the result of this deflection of the cerebral organs from the normal type, producing as it necessarily would, other arrangements of cerebral nutrition, and hæmostatic relations. It cannot be fortuitous that the mental characteristics of the most perverse criminals, and also the cerebral anatomy, both resemble those of wild beasts; this double analogy must be one of cause and effect.

Colored Photographic Prints.

This process consists in obtaining color photographs by means of two impressions from the negative, the first being a weak impression in order to give the outline for guiding the application of the coloring, and the second, after the colors have been applied, being an impression of sufficient strength to give the clear drawing, lights and shadows, and details of the picture.

In carrying out this process, I first take the negative in the ordinary manner. I then print on salted paper, already sensitized, a very light or faint proof of each negative, fixed and washed in the usual way. When dry I immerse the print for two or three seconds only in pure alcohol, then dry it again, and afterwards pass it through the rolling press. The print is then colored with an ordinary hair pencil in vegetable colors, the various tints being laid on smoothly, flatly, and lightly, without any regard to shading or softening off, but care being taken to have the tints brighter than they are intended to be finally. The colors are applied with the following mixture instead of with water:

Albumen of egg, 100 grammes; distilled water, 25 grammes; pure glycerine, 25 grammes; sal ammoniac, 5 grammes; liquid ammonia, 4 drops.

It will be found that the print will color more easily if it be slightly moistened and placed on a piece of glass. After the print has been colored, it is again passed through the rolling-press. When perfectly dry, the colored proof is immersed for a second time in pure alcohol, and is then albumenized in a bath composed as follows: Whites of eggs are beaten up with two grammes of very pure sal ammoniac added for every three whites of eggs, 20 per cent of distilled water, and about 4 drops of acetic acid for every 100 grammes of albumen. All is beaten up until the liquid attains a snowy appearance, when it is left at least eight days to stand. It is then decanted and ready for the colored print, which should be carefully passed over the bath and allowed to remain floating about sixty seconds. The print is then dried by heat, and finally passed through a sensitizing bath in order to be ready for the second impression. This bath is composed as follows: Distilled water, 1000 grammes ; nitrate of silver, 100 grammes.

The proof is again dried, but this time not by heat, and a second impression, stronger than the first, is then taken by laying the negative very accurately over the first impression, so that all outlines, etc., rigidly correspond. This has the effect of establishing the picture, throwing out high lights, etc. The proof is then toned and fixed in the usual way, and can be afterwards enameled.

A CURIOUS fact, and one bearing on the value of submarine cables, was mentioned by Mr. Pender, January 27, in presiding at the half-yearly meeting of the Eastern Telegraph Company. It was that the company had been able, for £10,000, to pick up from a depth of 2,000 fathoms one of their cables which had been ten years in the water. The establishment of the fact that it was possible to raise a cable from such a depth of course gives an additional value to all telegraphic property.

BELGIUM promises to become the great industrial teacher of Europe. Many foreigners are now attending her schools. She has 59 technical schools, 32 industrial schools, and a higher commercial school—all receiving funds annually from the State.

Analyses of Cows' Milk.

During the winter quarter of 1880 analyses were made of the milk of forty-two cows kept at the Government Agricultural Institution, Glasnevin, County Dublin, by Charles A. Cameron, M.D., Professor of Chemistry.

The morning's milk and the evening's milk of each cow were each analyzed once; and an examination of the mixed milk of the forty-two cows was also made.

The cows, it may be mentioned, were good animals; they had from one to three crosses of the shorthorn breed. They were in the house during the period of the experiments. Their food consisted of a daily allowance of from 8 to 10 stones of pulped mangolds and turnips, and exhausted grain from the brewery, together with from one-half to 1½ stones of hay. They were, therefore, liberally fed.

In every instance the quantity of milk yielded in the morning exceeded the proportion furnished in the evening. In two instances the morning's supply was three times more abundant, and in very many cases twice as plentiful. About eight hours intervened between the two milkings.

Thirty out of the forty-two cows gave richer milk in the evening than in the morning, and eleven cows gave richer milk in the morning than in the evening, while the remaining cow's milk was equally good at both milkings. The average amount of solids in the morning's milk was 13·20, and the evening's milk 13·74—a difference of 0·54 per cent. The increase in the amount of solid matters in the evening's milk was due chiefly to the larger amount of fats contained in the latter. The amount was 4·22 or 0·4 per cent over the proportion (3·82 per cent) found in the morning's milk. In the case of the mixed milk of the forty-two cows, that yielded in the evening was richer by 0·56 per cent of solid matters, including 0·44 per cent of fats.

The results of the analyses of the milk of these forty-two cows show that the mixed milk of well-fed cows in houses, in the last quarter of the year, contains, when poorest—*i. e.*, in the morning—13·90 per cent of solid matter, including 4·20 per cent of fats. On the 2d of November the mixed milk of eight cows, which happened to be in the same house, was analyzed. One hundred parts contained: Total solid matters, 13·90 per cent; solids, *minus* fats, 9·75; fats, 4·15; ash, 0·72.

The Society of Public Analysts of Great Britain and Ireland have adopted, as a standard for the poorest pure milk, 9 per cent of solids *minus* fats, and 2·5 per cent of fats—a total of 11·5 per cent of solids. There is little doubt that milk containing less than 11·5 per cent of solids is watered or skimmed.

The mixed milk of 100 cows kept on the dairy farm of Mr. E. M. Russell, Pery Square, was found to contain at the evening's milking 13·85 per cent of solid, including 4·60 per cent of fats and 0·72 per cent of ash. The solids, *minus* fats, were 9·25 per cent. The analysis was made in March, 1881.

I think there is the strongest proof that milk on the average contains more than 13 per cent of solid matters. During the last sixteen years I have examined an immense number of specimens of this liquid, and whenever I was certain that it was pure, I invariably found it to contain more than 12 per cent of solids. I am quite satisfied that the milk of Dublin dairy herds contains from 13 to 15 per cent of solids.

METHOD OF ANALYSIS.

Ten grammes of milk were kept in a shallow capsule in the water bath at 212° Fah until thoroughly desiccated; the residue showed the amount of total solid matters. The 10 grammes, dried and pulverized, were boiled in about 80 cubic centimeters of ether for several hours, an upright condenser being placed over the flask containing the ether to prevent a waste of the latter. The ether containing the milk fats in solution was filtered (a very small piece of filtering paper being used) into a light tared flask. The ether was distilled off, and the last traces got rid of by passing a current of hot dry air through the flask and condenser. The flask and its fatty contents were then weighed. The amount of the ash was determined by igniting at a low temperature in a platinum dish the residue obtained by evaporating 10 grammes of the milk to dryness.

It is perhaps, in part, owing to the great care taken to extract every particle of the fat that such high percentages of that ingredient were obtained.

In every instance the amount of solids was determined by two independent experiments. Many of the weighings of the fats and ash were repeated.—*The Analyst.*

Ultra Gaseous Matter in America.

On the occasion of Professor Carhart's exhibition of the Crookes experiments illustrating the ultra gaseous state of matter, before the New York Electrical Society, May 5, it was erroneously stated that the experiments had not before been publicly exhibited in this country. As shown in our issue of June 18, the same lecture, with the same experiments, had been presented to the Chicago Electrical Society, by Professor Carhart, January 24, 1881.

The Secretary of the Franklin Institute recalls to our recollection the fact that another early presentation of the subject, with illustrative experiments, was made in Philadelphia, February 17, 1881, by Mr. Alexander G. Outerbridge, Jr., of the U. S. Mint, whose lecture was published in the Journal of the Institute for April last. A still earlier exhibition of some of the Crookes tubes was made before the Franklin Institute, September 15, 1880, by Mr. Walton, of the house of Queen & Co., opticians, Philadelphia, through whom the apparatus was imported for Mr. Outerbridge's exhibition.

Cadaveric Alkaloids.

MM. Brouardel and Boutmy have communicated to the Académie des Sciences some further observations on the alkaloids developed in the animal body during decomposition—alkaloids which M. Selmi has termed *ptomaines*. According to Bouley and Lussana these substances may be developed not only after death but during life. It is still uncertain whether they are formed by simple chemical action or by the influence of minute organisms. The latter appear concurrently, but they may possibly be merely an indication that these alkaloids furnish a favorable soil for the development of this or that organism. The special object of M. Brouardel's researches was the discovery of means by which these substances may be distinguished from vegetable alkaloids. It is probable that the two have been sometimes confounded, and that this confusion has led to grave errors in medico legal investigations. It was so in a recent case in Italy, where an expert believed that he had discovered, in the body of a deceased general, evidence of delphinine; the reactions supposed to be proof of it were, however, certainly due to one of these cadaveric alkaloids.

The most effective method of distinguishing between the vegetable and the animal alkaloids is by making a complete examination of the chemical and physiological properties of the suspected substance; and if any one of these proper to a vegetable alkaloid is absent, it is probable that the substance is not this alkaloid, but a ptomaine which resembles it. This method is, however, tedious and difficult, and is only practicable when a considerable quantity of the suspected material is available. A more convenient method of distinguishing them is by the employment of ferricyanide of potassium. This substance is unaffected by the pure organic bases of the laboratory, or those extracted from the body of a person who is known to have been poisoned. The cadaveric alkaloids, however, instantly transform it into ferricyanide, and it becomes capable of forming prussian blue with salts of iron. The iodomercurate of potash gives similar reactions with both classes of substances, but the ferricyanide enables them to be distinguished. A few drops of a solution of the sulphate of the alkaloid are added to a solution of some of this salt in a watch glass, and then a drop of a neutral solution of iron determines the formation of prussian blue if the base is a ptomaine, and not if it is a vegetable alkaloid. Unfortunately there are two important exceptions to this test: morphia produces a similar effect, and so also does veratrine, but in a much less degree.—*Lancet.*

Sulphate of Ammonia from Gas Liquor.

The *Comptes Rendus* of the last meeting of the Société Technique de l'Industrie du Gaz en France contains a "Note" by M. Marché on the manufacture of sulphate of ammonia by a process which, unlike those in general use for this purpose, is applicable to small gas works. The process consists of the employment of crude sulphate of alumina, or alum cake, instead of sulphuric acid, as the reagent. This material costs about 2s. 6d. per hundredweight in the centers of production, and the authors of the process assert that in consequence of the high tariff imposed upon acids conveyed by rail, sulphuric acid would be less costly in the form of sulphate of alumina than in that of chamber or concentrated acid. The apparatus employed consists of (1) a wooden vat which is filled with liquor, to which the reagent is added in the proportion of 4·5 kilos per degree per hectolitre, and after standing from ten to 12 hours the liquor is converted into sulphate of ammonia; (2) an evaporating pan of sheet iron, in which the concentration of the liquor is effected by means of the waste heat from the ovens; (3) a small cask in which lixiviation is effected—the mother liquor returning into the pan and mingling with the liquor of other operations. The reaction is as follows:

The liquor contains sesqui-carbonate of ammonia, and in feebler proportion, hydrosulphate of ammonia. On coming in contact with the sulphate of alumina, the two salts are brought into the state of sulphate of ammonia, which remains in solution in the liquor. A precipitation of hydrate of alumina takes place, which completely purifies the liquor, while the carbonic and hydrosulphuric acids are liberated. The alumina is precipitated completely in twelve hours, and increases so rapidly in density that it may be taken out with the shovel when the cask is half empty. Therefore it is sufficient to remove, every three days, the excess of dense precipitate, which really contains but little sulphate of ammonia—not more than two per cent in fact.

The reaction is, therefore, complete. The advantages of the process are that the expense of fitting up the appliances is extremely trifling: there is not any expense for fuel, no supervision is needed, there is no wear and tear of plant, nor is any manipulation of the acid required, while the weakest liquors are utilized. The process is applicable to the smallest works, and also to those of the farthest removed from the works where the acid is produced, and with it there is the possibility of obtaining sulphate from the first distillation, owing to the purification effected by the reagent. With the same apparatus may be produced chloride of ammonium containing 30 per cent of ammonia, while the sulphate contains only from 24 to 25 per cent.