gauge line, and terminated at Blaenau Festiniog. The total length was about 12 miles, and, except at the stations, the line was laid with a single way. The summit-level tunnel was 3,860 yards in length. It was carried out by the staff of the London and North-Western Railway Company, the greater part of the remainder of the works being executed by contract. The tunnel-works comprised the sinking of three shafts, the driving of eight headings, and opening them out to the full size of the tunnel. The rocks perforated consisted of very hard members of the metamorphic system: and it was stated that at the south end, in passing under the Welsh Slate Company's works, great care was necessary, and a strong casing for lining was required to sustain the heavy weights above and around. The tunnel had an ascending gradient from the north end of 1 in 660 for a distance of 1 mile and 58·4 chains, followed by a level portion at the summit of 0·75 chain, and then a descending gradient of 1 in 660 for a distance of 36 chains to the south end. It was 18 feet 6 inches in height, and 16 feet 6 inches in width. The deepest of the three shafts slightly exceeded 143 yards, and all were rectangular, 12 feet by 6 feet, with the longer side in the direction of the line of the tunnel. The winding-machinery comprised, at each shaft, a boiler of the locomotive type, two small high-pressure engines, with spur-wheel and pinion and winding-drums: the latter were 6 feet in diameter, and the whole could raise a gross load of 30 cwt. at 8 feet per second. The timber head-gearing carried two pulleys, each 8 feet in diameter, and was fitted with Walker's detaching hook to prevent over-winding. The ropes were of steel wire, the breaking-strain being 20 tons. Five air-compressors were constructed to compress, to a pressure of 50lbs. per square inch, sufficient air to supply six rock-boring machines at each face. The compressor steam-generators were second-hand boilers. The pipes for conveying the compressed air to the workings were of wrought-iron, of 3½ inches bore to the bottom of the shafts and of 2½ inches bore from thence to the face of the workings. Superfluous water was raised to the surface, from a sump a the bottom: from two of the shafts by a wrought-iron vessel, attached to the under side of the cage, which filled and emptied itself automatically; but at the other shaft water was in excess, and a force pump had to be employed. The shafts were mainly sunk by hand labour. The Author then proceeded to describe at length the drill-carriages for supporting the machines, the drilling-machines themselves, and the modes of actuating them. At the north end of the tunnel an experimental drill-carriage was employed, in conjunction with electric-firing, with the view of taking out, as one large heading, the full section of the tunnel; but for want of success in electric-firing it was eventually abandoned, and the St. Gothard type of carriage and machine was substituted. It was equipped with six Ingersoll drills, fitted with automatic feed. At the south end a small drill-carriage was constructed, suitable for an advanced heading only, and provided with six Burleigh drilling machines with hand-feed. At the six intermediate faces the carriages were of the type adopted at the St. Gothard Tunnel, with Mackean drilling-machines, four at each face, driven by compressed air. Two forms of drill points were used, the chisel single-cutting edge for solid rock, and the cross-point for jointed rock. With regard to the workings at the bottom of each shaft, a top heading was driven in the first instance. Driving the advanced heading comprised three distinct operations, namely, boring the holes at the face, charging and firing, and removing the *débris*. Of the various explosives used, cotton powder or tonite answered well for the removal of rocks in unconfined places: but dynamite and lithofracteur were the most effectual in the advanced headings. The advanced heading was 8 feet square, and usually required from 15 to 30 holes 3½ feet deep, and from 1 inch to 2 inches in diameter, to remove a complete slice off the face. The operation of the drilling-machines mounted on the carriages was then described, a speed of 300 to 500 strokes per minute being attained: also the method of charging the holes and firing by hand, which was somewhat different to that ordinarily pursued. Following in the wake of the advanced heading in the top of the tunnel was the removal of the two sides. This was done principally by hand labour, and changed the section of the opening from a square to a semi-circle. The excavation of the lower portion was effected by driving a gullet along one side of about half the width of the tunnel to the full depth, leaving the other half for a roadway. The remaining portion was then attacked partly by hand, partly by machine-drills at various points. The Author next referred to the progress made at each of the shafts and headings, from which it appeared that the average upon the whole of the eight faces amounted to 14·09 feet per week. The total quantity of water finding its way into the tunnel was about 100,000 gallons per day. The total cost of the tunnel and three shafts complete, including labour, plant, materials and sundries was £302,850, divided as follows, viz., labour £203,000, plant 25,630, and materials and sundries £74,220. Allowing as a credit the half-cost of the plant of the plant, which it was assumed might eventually be realised, the reduced cost would be £75 per lineal yard, and taking the whole cubical contents of rock and other substances actually removed, the cost per cubic yard was £2 8s. 10d. The tunnel was opened for public traffic on the 22nd of July, 1879.

American Society of Civil Engineers.—Regular meeting, April 18th, 1883. Vice-President Perine in the Chair. The deaths of Messrs. John C. James, M. Am. Soc. C. E., of Winnipeg, Manitoba, and Simeon Sheldon, M. Am. Soc. C. E., of Cleveland, Ohio, were announced.

The Secretary stated that arrangements were well advanced for the Convention of the Society to be held at St. Paul and Minneapolis beginning June 20th. The ordinary meetings to be held at St. Paul. One meeting at which the President's address will be delivered to be held at Minneapolis. Members of the Society and their families will be accommodated at the Hotel Lafayette, Lake Minnetonka, and special arrangements have been made for trains to and from that hotel with reference to the meetings of the Convention. A banquet will be tendered by the Citizens of the two Cities at that hotel. It is also expected to make arrangements for a visit to the exposition of Railway Appliances at Chicago during the week previous to the Convention, and the Members of the Society will leave Chicago for St. Paul at a time to be announced on either June 18th or 19th. The attendance at the Convention will probably be very large.

A paper by the late Wm. R. Morley, M. Am. Soc. C. E. was read by the Secretary upon the Subject of the Proper Compensation for Railroad Curves upon Grades. Mr. Morley expresses the opinion that the resistance due to curvature is measured not by the length of radius but by the length of train, or what is the same, by the ruling grade and that while there may be some increased resistance due to radius, that may be largely overcome by the elevation of the outer rail, and that in the location of a railroad, the length of train, or ruling grade should be made the basis of Compensation, and not the radius of Curvature.

He gives examples in his experience where the practice of Compensation with reference to the radius resulted upon steep grades in a decided excess of Compensation, and in a noticeable increase of speed of the train upon curves. He also gives the rules adopted by him in his practice which were as follows:

Rate of max grade		per 100 feet	.05 per 100 feet per degree Compensation.
·00 to ·70	per 100 feet	.05	per degree
·70 to 1·60	"	·05	"
1·60 to 3·00	"	·04	"

The paper was discussed by Messrs. Bogart, Chanute, T. C. Clark, Emery Forney, Macdonald, North, Wm. H. Paine, D. Ward, and L. B. Ward.

In the discussion Mr. Chanute referred particularly to the paper by S. Whinery M. Am. Soc. C. E., published in the Transactions of the Society in 1878 on the Resistance of Curves, and the discussion upon that paper, stating that the theoretical resistances determined by Mr. Whinery agreed very closely with the practical results obtained by experiments upon ordinary wheels at low speed, and that the result was an addition of about one half pound per ton, per degree, to the resistance on straight lines, and that the equation for curvature resulting from this was about half of what Mr. Morley has adopted for his lighter grades.

The paper will be published in an early number of the Transactions, and will be discussed with others at the approaching Convention.

Meeting of April 4th, 1883: Geo. S. Greene, jr. in the Chair. As Members, Thomas Appleton, Council Grove, Kan., O. H. P. Cornell, Schenectady, N. Y., G. H. Elliott, Norfolk, Va., Orville Grove, Houston, Tex., W. G. Williamson, Martinsville, Va.: As Juniors, F. L. Fuller, Boston, Mass., A. McDonald, Nashville, Tenn.

The preliminary arrangements for the Convention were reported by the Secretary. The Convention is to be held at the Cities of St. Paul and Minneapolis, Minn. The party will arrive at St. Paul about noon on June 19th. Full details will soon be announced. It is intended also to arrange for a visit to the National Exposition of Railway Appliances at Chicago before proceeding to St. Paul. The death of Mr. Peter Cooper on the morning of the meeting was announced, and after remarks by Mr. Macdonald, it was ordered that an appropriate notice should be spread upon the minutes of the Society. A paper by G. Y. Wisner M. Am. Soc. C. E. on Geodetic Field Work was read by the Secretary in the absence of the Author and was discussed by Messrs. Haight, Prindle, Orves, and Geo. S. Greene, Jr.

Engineers' Club of Philadelphia.—Record of regular meeting, March 17th, 1883. President Henry G. Morris in the Chair; Mr. Chas. A. Ashburner read a paper on "A New Method of Estimating the Contents of Highly Plicated Coal Beds as Applied to the Anthracite Fields of Pennsylvania." The questions of the future production and ultimate exhaustion of these fields, are of the greatest importance. In 1860 the population of the United States was 31,443,321, and 8,583,-123 ton of coal were produced, i. e., actually shipped to market; in 1870 the population had increased 22 per cent (38,558,371) and the production of anthracite was nearly doubled, being 16,182,191 tons. For the year 1880, with a population of over 50 millions, the product was 23,437,242 tons. In 1882 the actual production was over 30,000,000 tons. It has been variously estimated that the 470 square miles containing this coal in Pennsylvania, will be entirely exhausted in from 140 to 204 years. While Mr. Ashburner does not estimate the ultimate exhaustion, he has devised a method for estimating the contents of these fields, from data now being obtained by the careful and practical geological and mining examinations of the State Survey. The exact position and detailed structural shape of the coal beds are first mapped by 50 feet contour lines along the floor of the beds, giving completely and satisfactorily, the geometrical construction and shape. These surfaces are then developed into planes, by the development into straight lines of the line of the bed as cut by parallelled section planes 1600 feet apart. This graphical method is attended with errors which are mathematically discussed, and which have been formulated by Mr. Arthur Winslow, Member of the Club. This method does not give the true area of the surface of a sphere, cone or triangular trough. In the case of a sphere, it gives $\frac{1}{4}$ of the true area; in a cone, the error increases directly as the secant of the angle which the pitch of the cone makes with its axis: and in a triangular trough, which more nearly represents the shape of the anthracite basins, the error is very much less. A practical test has been made of this method in the Panther Creek basin, between Mauch Chunk and Tamaqua, and the maximum possible error in estimating the surface area of the coal beds was found to be .965 of 1 per cent. After the areas are thus found, the contents are obtained by careful measurements made in the mines to ascertain the actual number of tons of coal which are contained in a unit (1 acre) of bed area. In this way it has been estimated that the above basin originally contained 1,032,000,000 tons; that the area under development originally contained 92,000,000 tons, out of which latter area 54,000,000 tons have been taken.

The Secretary presented, for Mr. John Marston, an illustrated set of formulæ for railroad turnouts and crossings.

Mr. John T. Boyd exhibited ribbons of phospho-bronze with which he had experimented with a view to its use for tape lines, in mine shop and other work, where the danger of breaking the ordinary steel lines is very great, and where the contact of the tape with substances, in themselves injurious to it, renders frequent wiping, and consequent scouring off of the figures, necessary. The phosphor bronze ribbon was found to be extremely tough, but, in addition to the difficulty in its manufacture into this shape, it was found that after it was bent at a sharp angle, it would not straighten out, thus decreasing the length of the line. As using the hammer to straighten it would increase the length, the experiment was not prosecuted further.

The Secretary presented a system of reduction tables which he had made to facilitate long and tedious multiplications and divisions.