

protects all of it, except the part in the furnace. This envelope consists of a double copper pipe, to the center of which there pass two small pipes, E¹, E². A current of water, quite independent of that which flows in the pyrometer, enters the envelope by the pipe, N, passes along its entire length, and escapes by the tube, O. The two tubes carrying the water used in the pyrometer are surrounded by a non-conducting covering; and in order that the refrigerating envelope may not have any influence on the pyrometer tubes, it is arranged that the water leaving it shall be at a mean temperature between the initial and terminal temperatures of the water in the tube, E. The pyrometer has been applied with much success to blast furnaces, glass works, porcelain and earthenware kilns, gas works, bake houses, and to many other apparatus requiring high temperatures. It is shown at the Inventions Exhibition, in Group II., at the stand of M. Brin, who exhibits a method of making oxygen, in the North Court of the South Gallery.—*Engineering*.

BOWLING GREEN HOTEL, KENILWORTH.

THIS property having recently changed hands, the present owner has commenced to replace the existing old-fashioned building with a large hotel, which he intends to be suitable for the accommodation of the numerous visitors to Kenilworth from all parts of the world. The walls of the building will be of red brick, with Bath stone dressings, and the gables will be half-timbered, as shown in the drawing. The internal accommodation comprises two large coffee rooms, public and private bar, bar parlor, billiard room, smoking room, club room about 30 ft. by 20 ft., large entrance

worlds and laws of navigation; theologians instructed in religion; musicians, poets, and painters entertained and delighted multitudes by their powers of melody, pictures, and song; physicians showed the laws of health and aided longevity; chemists explained the laws of combination and reaction, the mode of composition, and process of decay; none have left such stupendous and striking demonstrations of wealth, genius, and grandeur as the architect and the civil engineer.

Denon, the great French traveler and architect, well says, in speaking of the ancient Assyrian and Egyptian architecture, that it appears like a dream or the work of giants; and he fancied he saw on every stone the words "posterity and eternity." Should a peasant, he says, be drawn out from his mud cottage and placed before such edifices, would he not believe there existed a wide difference between himself and beings able to construct them? And, without any idea of architecture, would he not say, "This is the work of a god; a man would not dare to do it, nor inhabit it?"

War and defense, coupled with that quality of man's nature which constitutes the principle of sociality and love of home, that has been implanted in the heart of every race and type of the animal man, and is found to exist even in the lower animals and insects, indicate the primal necessity for the architect and engineer.

Man's love for his offspring, family, and social relations called for shelter, and as he grew in intelligence the necessity forced itself upon his mind of providing a permanent place of abode and protection, not only against the inclemencies of the seasons, but also against his own race and his more natural enemies, wild beasts.

If man is the resultant of the forces of nature, by a

cities, and very little is known of his progress in architecture.

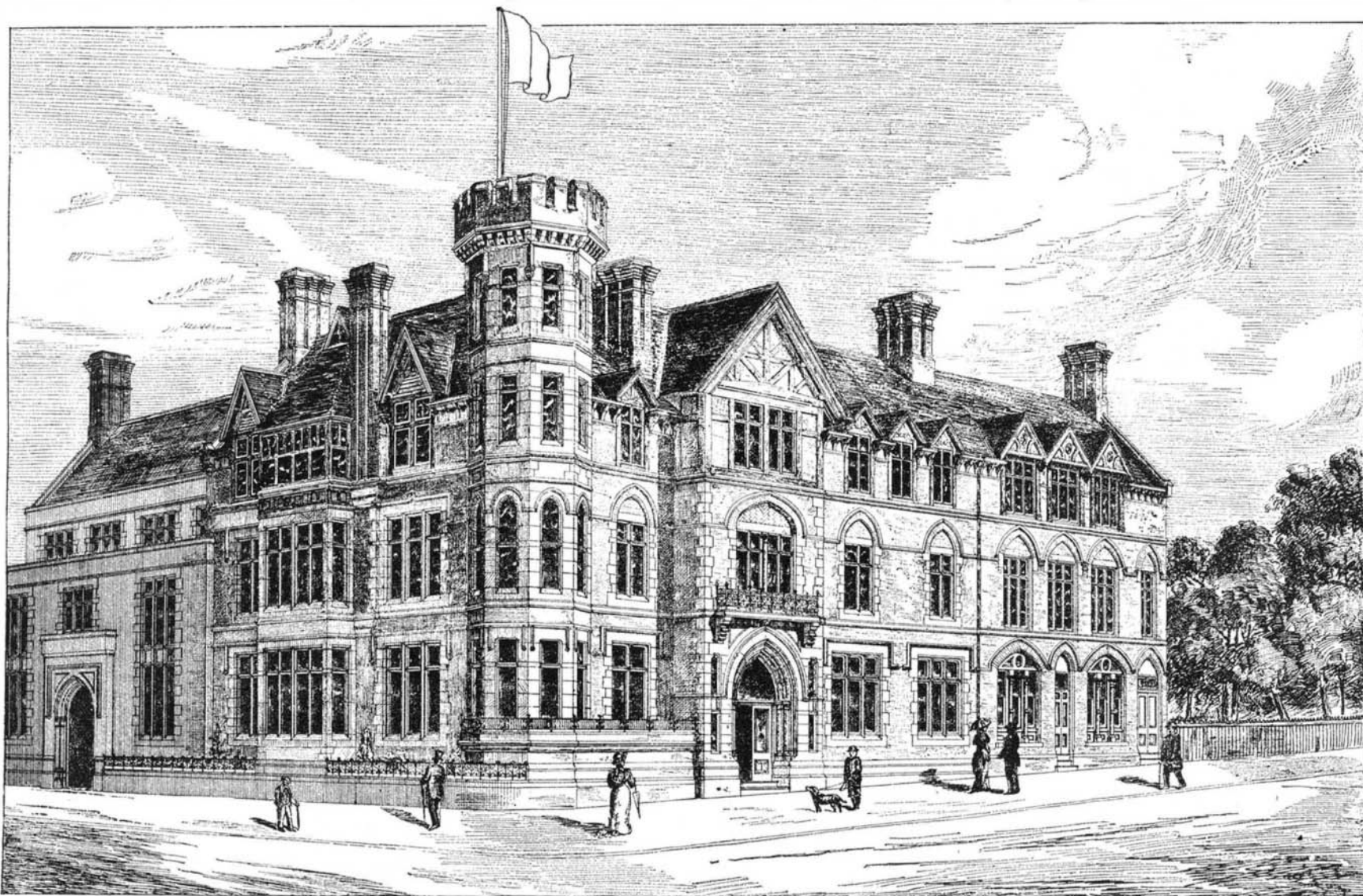
The first account, after this long lapse of time, seems to be of the building of the Tower of Babel, in which, it is claimed, that miraculous event, the confusion of tongues, occurred; and the fabulous mention of the city of Babylon.

Some Eastern writers give the height of the Tower as twelve miles, while St. Jerome more moderately asserts it was only four. The geographer Strabo, who may be relied on, says it was six hundred and fifty feet, which is more in accordance with our modern ideas and reason.

It is supposed that the city of Babylon and the Temple of Belus afterward occupied this same site. For a long period the whole history of this marvelous city is enshrouded in such a cloud of mysticism that it is exceedingly difficult for travelers or writers to determine anything reliable concerning it. It was founded 2,000 years B. C., and rebuilt 1,200 before the Christian era.

Nineveh, the splendid capital of the Assyrian empire, was sixty miles in circuit, and surrounded by high walls.

The accounts of the few travelers who long ago visited Asia and Africa were ridiculed and treated as extravagant fictions; but during the last century, and especially since the commencement of the present, the investigations of scientific men have verified these seemingly incredible narratives. Stupendous edifices remain to demonstrate the truth of these wonderful stories, while structures of surpassing magnificence astonish the traveler in Egypt, Hindostan, and Persia. When or by whom these everlasting monuments of



BOWLING GREEN HOTEL, KENILWORTH.

hall and staircase, two large sitting rooms on the first floor commanding a fine view, and 18 bedrooms, besides the usual kitchen accommodation, etc. The heights of the various floors, measured in the clear, are as follows: ground floor, 12 ft.; first floor, 11 ft.; and the second floor, 10 ft. The tower at the junction of the Rosemary hill and the Abbey road is 55 ft. in height from the ground to the top of the parapet, and a splendid and uninterrupted view of the ruins of Kenilworth Castle and the surrounding country will be seen from the top. Some curious deeds in the possession of the proprietor show the license of the property to be the oldest in Kenilworth. The architect is Mr. James P. Norrington, Birmingham; and the proprietor of the hotel, Mr. T. B. Cooper, Kenilworth.

WHAT CIVILIZATION OWES THE ARCHITECT AND CIVIL ENGINEER.*

By GEORGE R. BRAMHALL.

Of all the skilled professions, it is safe to assert that those of the architect and civil engineer stand in the front rank among civilized nations; not only for the wealth, convenience, and comfort they have contributed to society, but as the representatives of the grandest conceptions, the boldest achievements, that have been bequeathed either the Old or the New World.

And these achievements are of a character well calculated to excite in the mind of every intelligent being the highest degree of wonder and amazement.

While statesmen and jurists have framed wise and humane laws; the military defended them, maintained right, and put down rebellion; astronomers and mathematicians measured planets, given the movements of

long process of evolution (which is highly improbable), he had his first instruction in the art of building from the bee, ant, beaver, otter, musk-rat, and other animals.

This is not an unreasonable or unnatural conclusion, since he is first found dwelling in caves, hollow trees, tents, and mud huts, which show no greater evidences of skill in their construction and arrangement for protection, comfort, and convenience than those of the animals.

But these builders have made no progress in their mode of life, and we are forced to leave them in the same habitations they were found in five thousand years ago.

There seems to be conclusive evidence that man, although none the less an animal, was endowed by the Creator, at the beginning, with all the powers and faculties of reasoning we find him possessing to-day.

He has been traced, step by step, from the cave, tent, mud hut, log hut, and house of hewn logs, to the temples, churches, and cathedrals which adorn Europe and Asia, and the magnificent public buildings, legislative halls, palatial mansions, beautiful villas, and elegant homes of a free people, scattered all over these United States of North America, our own cherished land of progress.

The magnitude of the subject permits only a cursory view of the most notable ancient and modern achievements.

Those in the Old World commanding the greatest attention are the temples, cathedrals, churches, and aqueducts, and the reclamation of the Netherlands, better known as Holland.

There appears to have been a long period after the animal man emerged from his caves, huts of mud, and dwellings on piles (of which evidences are found in the lakes of Switzerland) before he is found in villages and

man's might were erected, the present inhabitants know not. Their antiquity dates back to a period shrouded in dark uncertainty, upon which authentic history throws no light. They are themselves the only, the mysterious, the indestructible records.

It is impossible to determine with certainty which of these three countries first brought architecture to the degree of excellence which these remains exhibit. Sir William Jones and other Orientalists contend for the superior antiquity of Hindostan, and assert that the East was not only the birthplace of art and science, but that they were there nurtured till they grew to manhood. While this may be true, there is also strong testimony on the side of Egypt. Here, it is supposed by some antiquaries, inventive genius in architecture arose, and thence spread through the civilized regions of the earth. Others trace it farther down the Nile, and consider Ethiopia the land from which light emanated.

The traveler in Egypt is filled with wonder and admiration at the number, size, and magnificence of the structures still standing upon the banks of the mysterious Nile. They are of three distinct orders: pyramids, excavations, and temples.

The famous pyramids, forty or more in number, of different sizes and of various materials, are scattered over a plain extending from Cairo about fifty miles along the Nile. Cheops, said to be five hundred feet high, is the largest structure in the world, or, in other words, the greatest mass of materials men have ever placed together to form a single building. A distinguished countryman says, "The oldest pyramid is yet the most perfect work of art, though it has stood more than three thousand years."

The temples, scattered in rich profusion on both sides of the Nile as far as the cataracts, are so numerous and interesting that it is exceedingly difficult to

* Read December 16, 1884, before the Western Society of Engineers. From the *Journal of the Association of Engineering Societies*.

know which to select for description. The splendid work prepared by the savants who accompanied Napoleon's expedition gives a perfect representation of these wonderful remains of Egyptian architecture.

Hundred-gated Thebes, spreading her solemn ruins on both sides of the river, shows the oldest specimens of true Egyptian art. Professor Heeren attempts to prove that Luxor, one of these old edifices, was a palace or building for civil purposes, though the general plan resembles a temple. He gives, among other circumstances, evidence to the effect that the occupations and scenes of daily life are depicted upon the walls of some apartments.

Among these mighty ruins must be mentioned the obelisks or monoliths. The sacred figures and hieroglyphic characters, beautifully cut in the hard granite, have the sharp finish of yesterday. The very stone looks not discolored.

Although the temples and other edifices of the Egyptians were painted with rich, bright colors, the character of their architecture was grave and sublime. "No people," says Champollion, "either ancient or modern, ever conceived the arts of architecture and sculpture on so sublime a scale as the ancient Egyptians. Their conceptions were those of men a hundred feet high."

The straight lines and angles, unbroken by a single curve, give to the outlines of their structures a heavy, massive appearance, and while there is a general resemblance in the plan of their edifices, there is infinite variety in detail.

They must have been a very numerous people and under severe despotism. Whether the despotism that could command such immense power was that of a cunning priesthood or a long line of ambitious monarchs, is uncertain. Probably the former, as most of the remains are temples dedicated to the worship of their deities. It is said that the wily priests exacted the hard earnings and ceaseless toil of millions to support an absurd, a monstrous, system of idolatry. To keep the people in awe and maintain their blind adoration, the temples of their idols must be imposing and magnificent. Thus what was at first a useful art became the most expensive and, considering the objects to which it was devoted, the most useless.

Yet, to the historian and architect, these grand remains are not useless, for they contain the chiseled record of the manners, customs, arts, sciences, literature, and religion of a portion of the human race which would otherwise have been buried in oblivion.

The ancient edifices of Hindostan resemble those of Egypt in form and general character, yet are sufficiently marked to produce a peculiar style. The stupendous and magnificent temples of the Hindoos, many of which were hewn out of perpendicular rocks, must have been constructed downward till the temple was finished where the foundations remain immovably fixed—a part of the primitive rock.

"The first view of the desolate religious city of Ellora," remarks Mr. Erskine, "is grand and striking, but melancholy."

The number and magnificence of the subterranean temples, the endless diversity of sculpture, the highly wrought pillars, rich mythological designs, sacred shrines, and colossal statues, astonish but distract the mind. No trace, he says, remains to tell us the hand by which they were designed, nor the powerful nation by which they were completed. The empire whose pride they must have been has passed away, and left no memorial behind.

The beautiful ruins of Persepolis, probably the summer palace of a monarch, which Alexander partly destroyed, afford a fine specimen of ancient Persian architecture. Le Brun, who spent three months in exploring them, conjectures that Darius and Xerxes were the builders. Others think Persepolis was built by Egyptian architects. That there was communication of architectural knowledge between the three countries possessing the most magnificent specimens of art cannot be doubted. The Jews, or Israelites, appear not to have gained much celebrity as architects, if the representations of King Solomon's temple we so often see are truthful. A seeming want in design has been concealed by everything costly and dazzling in decoration. In addition to this, it is said that when Solomon was about to build the structure, the workmen of his own kingdom were not sufficient for the task, and those of other nations were employed.

In China, the earliest attempts in architecture and building were close imitations of tents, and to this day there has been no departure from the original design. The discovery of ruins in Central America, immense in extent and perfectly anomalous in style, excited throughout Europe and our own country the most extravagant expectations. Scientific men looked for revelations of a race older than the Assyrians or Babylonians, but there are not sufficient grounds for belief in the great antiquity ascribed to them. In Greece, the land of the sage and philosopher, architecture reached its sublimest height. It is claimed by some to be the base of all the arts, and the one which first announces a degree of civilization, taste, and intelligence in a nation. Grecian architecture bears sufficient resemblance to the best specimens of the Egyptian to demonstrate that they had studied and improved upon that, and in their temples and public buildings their genius and art excelled that of all other nations. One of the most magnificent temples at Athens, dedicated to Jupiter Olympus, was built of the purest white marble. Art, in the zenith of her glory, could present no prouder shrine. Vitruvius says: "This structure is not spoken of with common praise. The excellency and sagacious contrivance have been approved in the assembly of the gods."

Among the Romans, the first efforts of architectural skill were employed upon walls of defense. The unadorned works, constructed during the early ages, were remarkable for solidity. They were built of large blocks of stone in the most substantial manner, thus proving the early ambition which projected, from its very infancy, the Eternal City, the capital of the world. It is said little can be granted the Romans as inventors, either in religion or architecture. They were simply imitators of the Greeks. Some claim the arch is a Roman invention, but arches have been discovered in ruins older than Rome itself. Splendid remains testify how successfully they employed principles acquired from the Greeks. These remains are public roads, aqueducts, temples, theaters, tombs, historical monuments, and forums. The Pantheon, their most celebrated temple,

was completed twenty-seven years B. C. It was allowed to remain by the Catholics, who gloried in its conversion to Christianity. Among churches, St. Peter's surpasses any, ancient or modern. Three centuries and a half this cathedral was building, while the cost is estimated at \$49,728,000. The base of the dome is 200 feet above the surface of the ground, and rises with its lantern and cross 300 feet higher. This is the wonderful cupola planned by Michael Angelo, one of the boldest attempts of architectural skill. Considering the number of pontiffs who ordered, and architects who planned, it is certainly wonderful that the proportions were kept inviolate, even to the most minute ornament. Michael Angelo left it an unfinished monument of his gigantic power, and his towering genius seemed to watch over his successors until its completion. Nothing ever surpassed, in effect, the interior of this church when illuminated at Easter by a cross of lamps suspended from the center of the dome. All travelers dwell with enthusiasm upon the glory of this scene. Second in magnitude and grandeur is St. Paul's, of London, whose first stone was laid in 1675. Completed in 1710, it was commenced and finished by the same architect, Sir Christopher Wren. The Grecian orders of architecture are largely mingled in both churches. Numerous magnificent churches of great size, built from the seventh to the tenth century and later, are scattered over Europe; St. Sofia, of Constantinople; Peterborough Cathedral, of England, erected by the Normans; Rochester Cathedral, during William the Conqueror's reign, and many others. Many bishops of this period are known to have been skillful architects.

The round towers scattered over Ireland are hobbies among writers. Peter Walsh, in 1664, says they were never known before the eighth century, and were built by the heathen Danes as watch towers. When the Danes were driven from the country, the Christian Irish used them as steeple-houses or belfries. These towers, nearly a hundred in number, are from 50 to 140 feet high.

A number of churches on the Rhine were constructed in the eighth century, and at Lorsch a building still exists which was part of a church consecrated in the presence of Charlemagne, in 774.

During the 12th century, Gothic architecture made its appearance, and was the prevailing style in churches through the greater part of Europe. Whatever its primitive elements, it was created in Northern Europe, and was adapted to the wants of a more inclement sky. If the origins of the Gothic style were various, no less so are the opinions as to the nation to which the invention belongs. It has been ascribed to the Hindoos, Egyptians, Hebrews, Romans, Greeks, Saracens, French, English, Germans, Italians, Spaniards, and Scotch.

The crusades in the 12th century drew the flower of European chivalry to the East, and vast numbers of ecclesiastics accompanied them. Since they were the repositories of art and science during that age, it is more than probable they brought home many novel inventions in architecture. There was also, at this period, a corporation of builders or free masons, consisting of Greeks, Italians, French, Germans, and Flemish, who kept secret the principles of their art, and traveled from place to place for the purpose of building ecclesiastical edifices. They had undoubtedly seen the finest specimens in the East, and would introduce whatever was suitable for Northern buildings, especially in ornamental parts. Some of the best Gothic architecture is found in England, Germany, and France. Westminster Abbey has been called by an English divine "the miracle of the world."

Cologne Cathedral is admired by many as the finest specimen of the Gothic in Europe. The richness of its decoration can scarcely be imagined.

Rheims boasts the most celebrated cathedral in France on account of its historical associations, immense size, and antiquity. The kings of France were crowned in this church, which was founded more than a thousand years ago. Here it was that the unfortunate heroine Joan of Arc placed the crown upon the head of the ungrateful Charles. Some critics, however, consider Amiens Cathedral the perfection of Gothic architecture.

The Spanish cathedrals, though surpassingly rich, lack the grandeur of those in Northern countries. Batalha, the glory of Portugal, was founded in 1385. The cathedral at Milan, a mountain of sculpture, has excited much admiration.

A popular traveler from our own country considers the famous Kremlin at Moscow one of the most extraordinary and beautiful objects ever beheld. It is two miles in extent, and is in itself a city.

Aside from temples and churches, there are multitudes of palaces and public buildings which attest the skill and genius of the architect.

And it will not be amiss to mention some of the noted buildings of our own country. Among these are the Capitol, President's House, Patent Office, General Post Office, and Treasury Building at Washington; Girard College, United States Mint, United States Bank, Masonic Temple, and City Hall at Philadelphia; State House, King's Chapel, and the Masonic Temple at Boston; Harvard College; Bunker Hill Monument; St. Paul's, Trinity, Grace Church, St. Patrick's Cathedral, Hall of Justice, in the Egyptian style, Merchants' Exchange, Herald Building, City Hall, Park Bank, and Equitable Life Assurance Building at New York; the State House at Albany; the Washington Monument; the Catholic Cathedral and Merchants' Exchange of Baltimore; and the Custom House, St. Charles Hotel, and Theater of New Orleans. These, with the capitols of the different States and the public buildings of the Northern and Western cities, will compare favorably, and are not surpassed, by structures of like character in Europe. They are lasting monuments to architects of the Old as well as the New World. While some claim that architecture is the base of all the arts, it is unquestionably of civil engineering.

This profession, though considered new by learned writers, was practiced among the Greek six or seven hundred years before the birth of Christ, as is shown by their canals, channels, and aqueducts for the conveyance of water. These were commonly structures of masonry to conduct water across a valley at a high level. Works of this kind are more properly called aqueduct bridges. It is necessary to bear this description in mind when dealing with the undertakings of the Greeks and Romans, for, since the former rarely if ever constructed aqueduct bridges, it

has been usual to institute very unfavorable comparisons between them and the Romans, who, with imperial disdain of obstacles, furnished the cities of their immense empire with a series of constructions of this kind which even in their ruins excite astonishment.

True to the difference in national genius, the Greeks followed nature, and seeing the water collected in hills, passing for miles along subterranean courses, then issuing in cool fountains at the coast, adapted their system of conduits to the physical formation of the district; cutting tunnels and canals rather than bridging valleys, and, as a consequence, no conspicuous monument of their system remains. Although they accomplished so little that Strabo is justified in charging them with neglect, in comparison with the Romans, yet it is clear from the records that in this, as in other respects, they were the instructors of the Romans.

The first Grecian aqueducts were constructed 625 years before Christ, and aqueducts, reservoirs, and tunnels were common in Athens 560 years before the Christian era, some of which supply the city to this day, and are described as marvels of enterprise and skill. They are built of stone, some having pipes of baked clay within. The system of conduits in Syracuse, which the Athenians partly destroyed, still supplies the town with an abundance of drinkable water, and the point at which the tunnel passes under the sea to the island of Ortigia presents what is regarded as a remarkable achievement for early times.

At Tusculum is an example of early Italian constructions for the conveyance of water. An oblong basin is divided into channels which receive the water of a spring and distribute it by pipes. The basin is built of blocks of stone overlapping along the sides until they meet and form a roof—a principle afterward supplanted by vaulting, and occurring in the earliest Greek masonry. If, to obtain a proper incline, the water course had to be carried above ground, it was supported on a stone wall, and the conduit built of blocks of stone coated with stucco, impervious to water.

Since a solid wall across a valley would cut off traffic, it was necessary to break it, by means of arches, into a series of pillars, and with this commenced the system of aqueduct bridges, which is the most striking monument of the Roman empire.

Perhaps the best known instance of this double purpose, an archway for traffic over which water can be conveyed, is Porta Maggiore, at Rome. The waters, taken over it in two separate channels, are Aqua Claudia and Anio Novus. From three inscriptions above the arches, it appears that the Emperor Claudius constructed the Aqua Claudia aqueduct from the springs Cacerutus and Curtius, forty-five miles from Rome; and the Anio Novus, from the sixty-second milestone from Rome; and that Vespasian and Titus restored them. Both aqueducts were commenced by Caligula thirty-eight years after the Christian era, and finished by Claudius ten years later. The length was sixty-two miles. Six miles from Rome the Anio Novus approached the Aqua Claudia, and from that point the waters traveled to the city in two channels, one above the other, supported by a chain of arches which at one place reached the height of 109 feet.

The Pont du Gard, as the aqueduct at Nîmes is called, consists of three rows of arches striding across the valley of the Gardon. In the lowest row are six arches, one having a span of 75 feet and the others 60 feet each. In the second row are twelve arches, each with a span of 75 feet, while in the third are 36 smaller arches, and immediately above is the water-course. As a bridge, the Pont du Gard has no rival for lightness and boldness of design among Roman remains.

Twelve more aqueducts at Rome, besides those already mentioned, assist in the supply of water. A system of regular reservoirs along the course of the aqueducts enabled repairs to be made at any point, and also let off water for the district they passed. A singular law decreed that material for repairs should be supplied from the private property nearest the damage; and what is still more strange, it was to be conveyed at the expense of the owner of the property. Public spirit or duty was at a high standard in those days; hardly as much could now be expected for the common weal.

Among aqueducts outside of Italy constructed by the Romans, and still existing, the most remarkable, aside from the Pont du Gard, are those at Segovia and Tarragona in Spain. The former is 2,400 feet long, with 159 arches of greatly admired masonry in two tiers, reaching a height of 102 feet; and the latter 876 feet long and 83 feet high. At Mayence are the remains of an aqueduct 16,000 feet long, carried on from 500 to 600 pillars. Similar witnesses of Roman occupation can be seen in Africa and Greece. The aqueduct at Metz, which originally extended across the Moselle, here very broad, conveyed from Gersa an abundance of excellent water. From a large reservoir at the source of the aqueduct, the water passed along subterranean channels, built of hewn stone, sufficiently spacious for a man to walk upright in. Similar channels received the water six miles from Metz, and conveyed it to the city. The bridge had only one row of arches, and the middle ones have given way, while the others are still perfectly sound. One of the principal bridges of the Antioch aqueducts is 700 feet long and at one point 200 feet high. The lower part consists almost entirely of solid wall, and the upper of a series of arches with massive pillars. Both masonry and design are very rude. The water was drawn from several springs four or five miles from Antioch, and conducted by channels of hewn stone into a main channel of similar construction, and was carried across streams and valleys by means of arches. Many of these old remains now serve as highway bridges, notably that near Spoleto. It has ten arches, remarkable for elegance of design and airy lightness of proportion, each over 66 feet span and about 300 feet in height. The one at Pyrgos, now supplying Constantinople, called the crooked aqueduct, is composed of three rows of arches, is 670 feet long and 106 feet in the deepest part. It conveys the waters of the valley of Belgrade, one of the principal sources of supply. The other is the high ground west of the town, from which the water is conducted by similar conduits. The supply from all sources is 400,000 cubic feet per day. Egypt and Babylonia presented a different system of water supply. Since both countries were flat and traversed by great rivers, by which they were regularly inundated, canals with large basins took the place of aqueducts. The stupendous scale on which in Egypt the waters of the Nile, and in Babylonia those of the

Tigris and Euphrates, were utilized was a marvel to ancient travelers.

The most remarkable aqueducts in France are those built in the reign of Louis XIV., for conducting water from Marly to Versailles. The famous aqueduct bridge of Maintenon, for conveying the water of the Eure to Versailles, is without doubt, in magnitude and height, the most magnificent in the world. It is 4,400 feet in length, upward of 200 feet high, and contains 242 arches, each divided into three rows, forming in all 726 arches about 50 feet span. The great works which supply Marseilles with the water of the Durance by a canal 60 miles in length are among the boldest undertakings of modern times. This canal, completed in 1847, is conveyed through three chains of limestone mountains by 45 tunnels, forming an aggregate length of $8\frac{1}{2}$ miles, and across numerous valleys by aqueducts, the largest, Roquefavour, surpassing in size the famous Pont du Gard. This immense volume of water, which passes at the rate of 198,000 cubic feet per minute, is carried across valleys by a channel of mason work, as in the old Roman aqueducts.

In British India, where the fall of rain is scanty and uncertain, artificial irrigation is resorted to. The Ganges canal, traversing the Northwestern Provinces of Bengal, distributes over this vast area nearly the whole volume of the Ganges. It begins where the river issues from the mountains, and 20 miles from its source crosses the valley of the Solani River, where the works for effecting the transit are designed on a scale of great magnitude.

Across the valley is an earthen embankment, raised on an average 17 feet. It has a width of 350 feet at the base, and 290 in the upper part. This forms the bed of the canal, and is protected by banks 12 feet in depth and 30 feet wide at the top. To preserve the banks from the action of the water, lines of masonry, formed into steps, extend on each side the entire length.

The river is crossed by an aqueduct 920 feet long, having side walls 8 feet thick and 12 feet deep. In grandeur of design, solidity, and utility, it challenges competition.

Croton Aqueduct, which supplies New York with water, is the only great work of this character in our country. At the time of its construction, it was justly regarded as one of the most magnificent works of modern times. Its length is $38\frac{1}{4}$ miles, and it is capable of discharging 60 million gallons per day. It is carried over the Harlem Valley in iron pipes laid upon a magnificent bridge 1,460 feet long, constructed of arches 114 feet above high water.

The water works of Manchester and the aqueduct at Glasgow are in some respects the most stupendous ever constructed, and have attracted a great share of public attention. The most recent, and perhaps most complete in detail, are the Vienna water works, and water supply of Paris.

The Vienna aqueduct is $56\frac{1}{2}$ miles long. In order to reduce friction and facilitate the discharge, the inside is plastered with a two-inch coating of Portland cement and sand. This is in three layers, the last a very thin one of pure cement, which when hardened was rubbed with iron plates till perfectly smooth and polished. It was completed in 1873, and supplies twenty million gallons per day.

It is said that Nature is responsible for the planets, but man made Holland. Its history is a subversion of the laws of nature, and its successes illustrate what the science of the civil engineer can accomplish. Fifteen hundred and fifty miles of sea dikes, some forty feet high and broad enough for roadways, are now existing, the result of a constant engineering battle and incessant toil. Nearly the entire region is below the sea level, and the perpetual security can be appreciated when it is remembered that in 1277 a single inundation destroyed forty-four villages, while in 1287 eighty thousand persons were swept away, and its present shape given to the Zuyder Zee. Thousands of acres of fertile land have been recovered from the sea; 12,731 square acres between 1833 and 1877.

In our own country civil engineering has been of the same practical character as in Holland; adding in the largest degree to the prosperity and wealth of the nation.

While we cannot boast so many aqueducts as France or Italy, in number and size our railway bridges are unsurpassed. The age of railroads brought this branch of engineering to a degree of perfection hitherto unknown, especially in the construction of iron and steel bridges. Wooden ones date back to a very remote period. The first we have any account of was built in Rome 500 years B. C. The next was erected by Julius Caesar for the passage of his army across the Rhine. Trajan's bridge, over the Danube, was made of timber, with stone piers. In the middle ages, when bridges were established as passages over rivers, they were usually constructed with piers, and were more notable for abundance of material than artistic skill. In this country the first wooden bridge of note is the one across the Portsmouth River of 250 feet span. Switzerland has several excellent wooden bridges. The most celebrated, that at Schaffhausen, built in 1757 by a village carpenter, was burned by the French after it had been in use 42 years.

The Romans built the first stone bridge. It was over the Tiber. Twice rebuilt, the remains of the last structure are still visible. Pons Aelius had originally a roof of bronze supported by forty columns. Destroyed by the barbarians, it was restored by Clement IX., who placed on it colossal statues of angels carved in white marble.

In Egypt and India, the birthplace of so many arts and sciences, arched bridges were unknown; neither are they met in the ancient remains of Persia or Greece, though their architecture was the finest in the world.

The first stone bridge over the Thames, known as "old London bridge," was completed in 1209.

The novelty of Westminster bridge was the manner of laying the foundations. This was effected by means of caissons, and inaugurated a new era in bridge architecture.

One of the most remarkable wooden bridges is at Havre de Grace. It is 3,271 feet long, and divided into twelve spans resting on granite piers. Constructed on Howe's plans, it combines great lightness with strength.

Washington Aqueduct bridge has some novel features. Its arches are of cast-iron pipes, which carry the roadway and water supply at the same time. The bridge at Louisville, the truss bridge at Rock Island, the St.

Louis bridge and others on the Mississippi, are noted both for design and strength.

Suspension bridges are of remote origin. Kirchen in his "China Illustrated" mentions one of chains supporting a roadway 830 feet in length, built A. D. 65. It is still to be seen.

The Peruvians constructed bridges over the Andes, the principal material being rope made from the bark of trees. Sometimes there were roadways, at others the transit was effected by a basket drawn alternately from side to side.

Iron suspension bridges, however, are of modern date. The first in England was built by Capt. Samuel Brown in 1819, across the Tweed. It was made with 12 chain cables, and the span was 449 feet. Several built in Scotland on the same plan were destroyed by hurricanes.

Pesth suspension bridge was opened in 1849. The clear water-way is 1,250 feet, and the towers 200 feet from the foundations.

In the United States the first one was built between 1796 and 1810, of chain cables. During the last 25 years wire cables have been universally adopted. Roebling's suspension bridges at Niagara and Cincinnati are the finest of this type in the country.

His bridge to connect New York city with Brooklyn is, without doubt, the grandest and most imposing structure in the world. It is 3,475 feet long, 135 feet high, and cost \$15,000,000.

The cantilever bridge at Niagara has justly been pronounced a marvel in the science of bridge building. It is almost entirely of steel, and is 910 feet long.

Rush Street bridge, at Chicago, Ill., designed by Mr. Samuel G. Artingstall, is the largest general traffic drawbridge in the world, the roadway accommodating four teams abreast. It is swung by steam power and lighted by electricity. For symmetrical proportions, completeness and elegance of design, it has no rival.

Tunnels are of very ancient origin, and were common in Rome several hundred years before the birth of Christ. 398 B. C., a tunnel, 6,000 feet long, 6 feet high, and $3\frac{1}{2}$ wide, to tap Lake Albanus, was completed in one year.

When Caesar arrived at Alexandria, he found the city almost hollow underneath from the aqueducts. Every dwelling had its reservoir, supplied by subterranean conduits from the Nile.

The aqueducts of the Romans, Peruvians, and Mexicans included remarkable tunnels.

Among the celebrated tunnels of modern times are Mont Cenis, St. Gothard, Noehistongo, Sutro, Riquelme, Blaizy, Thames, and Medway, and Chicago lake tunnel, which attracted much attention in Europe during its construction.

Canals are of still greater antiquity. The Assyrians and Egyptians built them first for irrigation, and afterward for navigation. They are now common in all civilized countries, notably in Holland.

Mr. Charles B. Stewart, civil engineer, in his "Lives and Works of Civil and Military Engineers," published in 1871, says that to the United States justly belongs the credit of building the longest canal in the world in the shortest time, for the least money and to the greatest public benefit. The Erie Canal, completed in 1825, is rightly claimed to have exerted an influence that beyond computation exceeds any investment of money ever made in any nation. Not only great States that border on the great lakes owe their prosperity, but the States beyond the great river Mississippi must forever find their markets through its channels to the Atlantic cities. Other and more rapid modes of transportation have diverted public attention from this pioneer improvement until few are aware that in the extent and value of its tonnage it far exceeds the whole foreign commerce of the United States.

In the remote and far East, many of the earliest and some of the greatest achievements of the architect are of a character to baffle the most learned antiquaries. They are unable to determine for what use or purpose many stupendous structures were created. Had not the library at Alexandria been destroyed, it would doubtless have thrown much light on problems that must forever remain a mystery. And the question is, Has any benefit ever been derived from the construction of these mighty edifices, whose ruins bear silent and solemn testimony of the untold millions which have been expended, and of cruel servitude exacted to gratify the ambition and vanity of kings and tyrants? A country may be richly adorned with temples, palaces, and hanging gardens which surpass even the Garden of Eden, and yet the masses be in the most abject and deplorable condition. To constitute real wealth and power, a country must possess other conditions. Among these are a just and liberal government, which is the foundation of a free and happy people, and great resources, both agricultural and mineral. These, with her manufactures, commerce, public highways, buildings, libraries, and schools, make a nation truly great. Our own country possesses all these in an eminent degree. No nation, ancient or modern, ever made such gigantic strides in public improvements and works as the United States in the last fifty years, and the civil engineer has performed a most conspicuous part in contributing to her wealth and power. There is no uncertainty, no question, in regard to his achievements, which bespeak their real purpose to society from the very beginning. As evidence of the benefits bestowed upon society of modern times by engineering skill, it is only necessary to refer to the most noted, the railroads and ocean telegraphs. The first railroad in the United States, known as the Quincy, was constructed in 1826, and the Manchester and Liverpool road was completed about the same time. Up to 1882, Europe had 107,406 miles of railway and the United States 104,813, that of the former being about 2,600 miles in excess of this country. Illinois has the greatest number of miles of any State in the Union, and 504 more than the New England States and New Jersey combined. These roads, extending from East to West, span the continent, making it possible for one to travel from the Atlantic to the Pacific in a number of days that would have been months fifty years ago, and with a degree of ease and comfort inconceivable at that time.

Gigantic mountains, mighty rivers, and deep valleys are no obstacles to travelers or traffic since the skill of the civil engineer has divided continents by ship canals, tunneled the Alps, Hoosac, Alleghenies, and Rocky Mountains; bridged the great rivers of the world and filled valleys; an apparent fulfillment of St. Luke's

declaration eighteen hundred years ago, that "every valley shall be filled, and every mountain and hill shall be brought low; and the crooked shall be made straight; and the rough ways shall be made smooth." Could language be more prophetic or more in harmony with the achievements of the civil engineer in the nineteenth century? When civilization and its varied interests made it necessary to have daily and hourly communications between the Old and New Worlds, the electric and naval engineer supplied the want by joining the two continents by a band of iron—the submarine telegraph by which the great commercial and financial transactions of the two continents are largely maintained. Messages of love, sorrow, and respect between friends, and the comity of nations, may be exchanged at pleasure and with the rapidity of the lightning.

It has been said man made Holland; with equal force it can be stated the architect and civil engineer made Chicago, a city whose relationships, characteristics, and rapid growth have no parallel in history. General Watson Webb, lately deceased, in a recent letter to the Hon. John Wentworth, says that in 1822 there was neither house, hut, nor shanty of any kind, except those occupied by the employees of the government, other than those of John B. Beaubien and John Crafts. The first hotel was opened in 1826, when Chicago contained five houses. In 1830 the town was platted, and a year later the population numbered 75, and the cabin hotel gave place to a two-story building called the Sauganash. In 1833 Chicago attained the dignity of an incorporated village. The limits were made on the north to Ohio Street, south to Jackson, and west to Jefferson, and it contained 550 inhabitants and 175 buildings before the close of the year, although there were only 29 voters at the time of organization. Chicago's first public loan, \$60, was negotiated in 1834, and applied to making a ditch on each side of Clark Street. In 1837 Chicago became a city, with an area of about 10 square miles, and a population of 4,100. The hydraulic company, designed to supply Chicago with water from the lake, was incorporated in 1848. In the same year the Galena Railroad was begun, which with the Illinois Central, commenced in 1851, was the introductory to that great system now represented by 18 trunk lines, which makes this city the greatest grain, lumber, and provision mart in the world.

In 1857 the grade of the city was raised from 5 to 12 feet. One of the finest opera houses in America was built in 1864, and the lake tunnel begun. The construction of our present system of water supply attracted much attention, not only in our own country, but also in Europe. This was due to the novelty of taking water down from a great lake for domestic and manufacturing purposes. Although tunnels had been constructed hundreds of years before the Christian era, this feature of engineering skill belongs entirely to Chicago and the nineteenth century. Millions have been expended in perfecting this grand system and in the erection of one of the largest pumping engines in the world, whose ponderous movements denote the power and purpose of the designer in supplying to this city one of the most essential elements to mankind with as great a degree of regularity in its pulsation as the human heart in supplying the life-giving current.

In 1871 the city area embraced nearly 36 square miles, and the population was 325,000.

On the 9th of October, 1871, one of the most destructive fires in the world's history occurred, burning over 2,124 acres and destroying 17,950 buildings, thus rendering 98,000 people homeless. Not only has this vast expanse of desolation and ruin entirely disappeared, but a new city has been virtually erected, which is not surpassed in its architectural beauty, number and magnificence of its public buildings and business blocks by any on the face of the globe.

Hon. De Witt C. Cregier, Commissioner of Public Works (our late worthy President), says in his report to the Common Council in 1882, referring to official records of a petition bearing date Aug. 13, 1835:

"Your petitioner respectfully represents to your honorable body, that he has graded and thrown up La Salle Street, between South Water and Lake, in front of lots one and two, and begs to be allowed the cost or value of said work, to be deducted from the taxes of the ensuing year.

"GURDON S. HUBBARD.

"To the Trustees of the town of Chicago."

He adds that the author of this is now a hale and active resident, who has witnessed Chicago grow from a frontier village to its present important place among the great cities of the world.

In his report for 1884 he has suggested public improvements which, if carried out as outlined, will make Chicago the most wonderful city in the world, although less than half a century ago it was nothing but a swamp and quagmire, at seasons impassable to man or beast. Chicago in the future, as in the past, will be the theater of the civil engineer, who has raised her from a marshy slough, paved her streets, constructed her labyrinth of sewers, erected great water-works and pumping engines, built splendid iron viaducts and drawbridges, one of which has been acknowledged the largest of its kind in the world, and supplied her with a network of street railways which, in detail, are the most complete in the system of street railways. With all these achievements, the city has but entered upon the threshold of her unsolved problems, which will require in their solution still greater power and skill in the engineer, and this hall will be a fitting place to discuss these questions and the plans for their execution. In all probability there are members of this society, and in all likelihood there are some now within sound of my voice, whose names will be enrolled with those of Geddes, Williams, Wright, Douglass, Latrobe, and Roebling, in the future history of the profession and our country. In conclusion, does it not seem fitting to ask Civilization to whom she is indebted for the great achievements which adorn the world; to which of the skilled professions is due the wealth, convenience, and comfort enjoyed by all classes? Without one word of disparagement to any of the noble professions and arts which have contributed so largely to the power and progress of the present age, I repeat, none have left such monuments of wealth, genius, and grandeur as the architect and the civil engineer.