The average duration of vitality in seeds of some of our cultivated plants is as follows: Artichoke, five years; broad bean, six: beet root, five; cabbage, five; carrot, four; cucumber, five; lettuce, five; maize, two; melon, five; onion, two; parsnip, two; peas, four or five; radish, five; spinach, five; tomato, five; turnip, five; egg plant, seven; endive, nine; parsley, three; strawberry, three. An analysis of these figures shows a general agreement in the constitution of the seeds of different plants of the same families, with exceptions which can be accounted for in the way already explained. Exalbuminous seeds, and those with very little albumen, retain their vegetative power longer than seeds with a minute embryo and a relatively large quantity of albumen. Taking a broader survey, the rule holds good that the more highly developed embryo, whether small in itself or large, will lie longer dormant without losing life than the large or small embryo of albuminous seeds. Sir Joseph Hooker has stated that the seed of *Nelumbium speciosum*, taken from a herbarium known to be upwards of one hundred years old, germinated. This seed has an exceedingly dense testa.

FORMATION OF AMERICAN COAL.

The base of our coal measures is a rock, called the great conglomerate, which is chiefly composed of white, water-worn pebbles. Its composition proves it to have been the bed of an ancient sea; and that a great sea existed in the eastern half of our continent is a fact well known to geologists, who have traced it from the Rocky Mountains to the Blue Ridge. In this wide expanse of water the coal deposits of our country were formed beyond a doubt. It was a wise provision of nature to lay for their base the thick and strong conglomerate rock, as the violence of volcanic action in that early period was so great that a weaker barrier would have been broken, and the coal would have been destroyed by denudation. The 200,000 square miles of American coal are divided, by Prof. Rogers, into five great fields, of which the first, or eastern, includes the coal deposits of Newfoundland, Nova Scotia, Cape Breton, and New Brunswick. The second, or Alleghany coal field, is the largest, and extends from Pennsylvania and Ohio, southwestward, into Georgia, and includes the anthracite fields of eastern Pennsylvania. The third is a small field, known as the northern, occupying the central part of Michigan; and the fourth is the central field, including parts of Illinois, Indiana, and Kentucky. The fifth or western field, lies west of the Mississippi, principally in Iowa and Missouri, but extends into Arkansas.

Besides these well defined fields, we have, further west, the uncertain deposits of the Black Hills; but as the thickness of the American coal measures regularly decreases from east to west, the seams that may be found on the eastern slope of the Rocky Mountains must be very thin and scarcely workable. In the east, where the coal formation is thickest, there are in all about fifty seams, but not half of them are of sufficient thickness to be worked. In Nova Scotia only five are of workable dimensions, and these produce about twenty-five feet of coal. In the anthracite region, the number of productive seams is about twenty-five, and they average in some sixty feet of coal, but their maximum yield is somewhat over a hundred feet. The largest of the anthracite veins is the "Mammoth," which is thirty feet thick. In the Alleghany region the average thickness of workable seams is about half that of the anthracite fields; and in the western fields it is only about ten feet. Thus the number of seams, and the quantity of coal, decrease from east to west; as also the thickness of the intervening strata of rock. The greatest depth of the coal measures, including these strata, is 3,000 feet.

It is supposed that coal was formed during the carboniferous era, when the earth and the atmosphere were in a condition to produce an unlimited and gigantic growth of vegetation.

That the coal beds had their origin during this vast vegetable growth, is a well attested fact; but the process by which the carbon and bitumen of that rank vegetation were concentrated and solidified, is a point on which scientists differ. The fact that there is no sign of vegetation in pure coal, indicates that the component parts have been expelled by heat or pressure, in the form of oil. If accumulated vegetation or woody fiber had formed coal, it would doubtless be fossiliferous. It seems natural, therefore, that the enormous oil deposits of the carboniferous era, resulting not only from resinous vegetation, but also from the countless myriads of marine animals, when accumulated in localities having the requisite conditions, formed beds of coal. Great quantities of this oil were evidently sealed between rocky strata, and thus kept from solidifying, for want of exposure; and from these reservoirs issue the numerous oil springs of the present day. Herodotus, more than two thousand years ago, referred to a spring on one of the Ionian Islands, which is still flowing. The Chinese *Hotsing*, or wells of fire, are gaseous petroleum springs, and are made of much practical service in evaporating salt water. There is a similar spring in Fredonia, New York, south of Lake Erie, the gas of which is used for lighting the town. Genoa and Parma, in the north of Italy, are similarly lighted. In Cuba petroleum springs are very numerous; and between the fissures of rocks it has consolidated in the form of bitumen, which is used for fuel. When petroleum is thus solidified by exposure to a moderate heat, it bears a strong resemblance to bituminous coal; but under a higher temperature, the hydrogen and oxygen are evaporated, leaving a comparatively pure carbon, resembling anthracite; and when subjected to an intense heat, the carbon is also vaporized, leaving only the impurities.

The best anthracite coal contains about ninety per cent of carbon, which is rendered gaseous by the ordinary process of combustion. From these facts we may infer that the various kinds of coal are due to different degrees of heat to which they were exposed during formation. The oily cannel coal was evidently formed with little heat, the ordinary bituminous with more, while the hard anthracite was subjected to such a degree of heat as left it nearly a pure carbon.

Oil being lighter than water, it readily accumulates on the surface of lakes, and on long exposure it forms a sheet of bitumen, or pitch, which in winter is hard, so that a man can walk on it with safety. There is such a lake on the island of Trinidad, one of the West Indies; and similar lakes are known to exist in other volcanic regions. Hence, during the periods of vegetable and animal oils, and of extraordinary volcanic activity, producing, no doubt, an abundance of oil directly from mineral sources, it is reasonable to suppose that immense bodies of water were thus covered to a great depth with plastic coal. The time of such formation necessarily corresponded with a period of volcanic inactivity. While forming, the sheet may have been occasionally sprinkled with a slight shower of ashes, causing an impurity in the coal, such as slate or bone; and a rent in the sheet, caused by contraction, may account for the fact that the miner sometimes suddenly loses the vein, and must grope for it through the rock. When volcanic action revived, the greatest imaginable changes must have taken place, to account for the strata of rock overlying the seam. Between some of the seams the stratum is over two hundred feet thick. Showers of ashes or streams of lava may have sunk the sheet to the bottom, when, during the next period of inactivity, another seam may have been formed to be submerged in like manner, but perhaps with a stratum of only a few feet in thickness.

That these strata decrease in thickness from east to west, may be attributed to the well known geological fact that volcanic activity was greatest in the eastern section of our continent; and as the seams decrease in like manner, we may infer that coal owes its origin chiefly to volcanic sources.—*By Moses Zweizig, in Christian Weekly.*

PLANTS OF THE CARBONIFEROUS PERIOD.

NEW USE FOR CYPRUS REED STEMS.

Mr. John R. Jackson, of the British Museum, referring, in the *Gardener's Chronicle*, to the enormous trade now carried on in London in the manufacture of walking sticks and parasol handles, says that, notwithstanding the large number of these useful and ornamental articles that are constantly being produced, and the consequent demand for certain kinds of sticks, there is every now and then a utilization of something quite new, and different from anything that has hitherto preceded it. Such, for example, was the discovery and adaptation of the fasciated stems of the fuller's teasel, which some two years since were imported in vast numbers from France for the sole purpose of converting into parasol handles. At a recent meeting of the Linnæan Society specimens of a newly introduced cane were exhibited both in the rough and finished states. These canes were at first thought to be derived from a species of bamboo—*Bambusa nana*—and hence received the trade name of "Nana"; but it was afterwards discovered that they were from the Cyprus reed (*Arundo donax*). The peculiarity which has caused them to be taken up for the purpose to which they are now applied lies in the irregular and fantastic forms of the rhizomes, and especially in the ring-like ridges which encircle these rhizomes at regular intervals. Owing to the combined form, surface markings, and natural yellow tint, which harmonizes so well with the coverings used, a more unique handle for a parasol could hardly be produced. These articles have now become quite the rage, and may be seen in large numbers in the show windows of fashionable stores. The Cyprus reed is a robust grass, growing fifteen feet or more in height, with abundant leaves and very large terminal panicles of a brownish-white color. It is found in southern Europe, eastern Asia, and on this continent in Texas and Mexico, and is apparently the reed mentioned in Scripture. The uses to which the plant has hitherto been applied are as supports for vines, for fishing rods, etc.

Functions of the Air Bladder in Fish.

In a paper read at a recent meeting of the Cotteswold Naturalists' Field Club, by Mr. Francis Day, the author remarks that few among the organs in fishes have been the cause of so much discussion as the air bladder, which is a single or variously divided sac, situated beneath the vertebral column and the kidneys, and placed above the center of gravity. As this organ is sometimes present or absent in species of the same genus, it is evident that it is not entirely indispensable to the fish's existence. It originates as an offshoot from the stomach, elongates, and then enlarges at its extremity into what is termed an air bladder. In the dipnoids the air bladder communicates with the œsophagus during life, and its functions are analogous to those of lungs. In *Amia*, a ganoid fish, it has also a lung-like function, but in *Acipenser* it is used merely for hydrostatic purposes. The air bladders, however, are not considered as lungs in most fishes, since the blood is supplied to them from the adjacent arteries, and in many cases returns as venous blood into the circulation. In *Lepidosiren*, however, in consequence of the non-development of gills on the two inferior branchial arches, the blood is not arterialized there, but passes on to the air bladder for this purpose. The lepidosirens are doubtless the highest known form of living fishes. The chief use of the air bladder in teleostean fishes is (1) hydrostatic; (2) acoustic, it being partially or entirely employed for hearing by means of various modes of connection with the internal ear.

In the *Physostomi* the air bladder occurs as a closed sac. In the marine forms of these orders a tubular prolongation itself passes forward to the anterior portion of the skull to establish an auditory communication, but in the fresh water species the connection is formed by a chain of auditory ossicles. In conclusion, Mr. Day says that the air bladders in fishes is the homologue of the superior vertebrate forms, and that in some of the higher sub-classes it serves as an accessory respiratory organ.

Amplifying Small Motions.

At a recent meeting of the London Physical Society Mr. Ridout exhibited a device for amplifying small motions. A small barrel is slung by two threads between the prongs of a metal fork in such a manner that if the fork is bodily carried to and fro the barrel will rotate round its axis. This is simply effected by making each thread, in its passage from one prong to the other, take a few turns round the barrel. To the barrel an index is attached, and the fork is then fixed on the body whose minute motion is to be indicated. The translation of the body shifts the fork and rotates the barrel, which in turn deflects the index round the face of a dial, and the magnifying power is expressed by the ratio of the diameter of the barrel to the length of the index. With this apparatus Mr. Ridout exhibited the lengthening of an iron core when magnetized by the passage of the current of two Grove's cells through an insulated wire coiled round it. By riveting a slip of brass to the iron the unequal expansion of brass and iron under heat was also shown, the heat being generated by keeping the current flowing in the coil.

Mr. D. Winstanley exhibited his new radiograph for recording graphically the intensity of solar radiation throughout the day. It consists of a differential thermometer, with one black bulb and a circular stem. The lower part of the stem is filled with mercury; the upper branches with sulphuric acid and water. The tube is mounted on a brass wheel, so that when the black bulb is exposed to the sun's rays the differential motion of the mercury causes the wheel to turn. The wheel carries a light index or marker, which is free to traverse a vertical cylinder covered with paper coated with lamp-black, and leaves a white track where its point has scratched off the soot. The radiogram thus produced can be fixed and preserved.

Dr. Guthrie pointed out the curious "thermal twilight" these radiograms had betrayed to Mr. Winstanley. They show that before sunrise the temperature increases, owing to solar radiation. Moreover, half an hour after sunset the index falls, and remains till within a few minutes of midnight, when it mysteriously rises and sinks again, although the sun is then directly over the opposite hemisphere.

History and Progress of American Water Works.

The first works in America for the supply of water to towns were constructed by Hans Christopher Christiansen, and put in operation June 20, 1754, at the Moravian settlement of Bethlehem, in Pensylvania.

The water from a spring, which is still used for the supply, was forced by a pump of lignum vitæ of five inches bore, through hemlock logs into a wooden reservoir.

The same ingenious Dane, eight years later, replaced this rude pump by three iron pumps of four inches bore and eighteen inches stroke, which for many years were the only machinery for water supply on the continent, and for seventy years furnished the water for Bethlehem.

Among the oldest, if not the very next in date to Bethlehem, is the Morristown, N. J., Water Company, which was incorporated in 1791, and has ever since furnished the town with water collected from the neighboring hills.

The first application of steam to pumping was in Philadelphia, in 1800, when the third steam engine of any considerable size in the United States was erected on the banks of the Schuylkill. It is believed that these works were the first constructed by a municipality. The first cast iron water pipes were laid in Philadelphia in 1804.

New York was first supplied by a company which erected a small pumping engine about 1800.

During the first thirty years of the century several small works were constructed, among others, at Cincinnati, in 1817; at Detroit, in 1827; at Lynchburg, in 1828; Syracuse, in 1829; and Richmond, in 1830. Few of these works exhibited any great advance in engineering. The enlarged works for the supply of Philadelphia by water power, constructed at Fairmount, in 1822, showed, however, a marked advance, and were for many years regarded as a model of efficient and economical works. The design and execution of the gravity supply works for New York and Boston, between 1830 and 1840, were such as cannot be greatly improved, even at the present day, except in some minor details.

About 1850 the substitution of light wrought iron pipe, lined inside and out with hydraulic cement, for cast iron, at greatly reduced cost, was found to be practicable in many cases, and the formation of companies to manufacture and lay such pipes, introduced a commercial element into the matter of water supply, and led to the construction of many works.

Improved forms of pumping machinery, which performed a fair duty at small expense for construction and maintenance, were designed and their manufacture became a special business.

The careful analysis and investigation employed in the construction of the works for the supply of Brooklyn, between 1850 and 1860, resulted in a more decided advance, in both theoretical and practical science, than had hitherto been made, the effects of which were seen during the succeeding decade in improvements in pipe manufacture, in engine building, in reservoir construction, and in maintenance of works.

Between 1860 and 1870 a further impetus to water works construction was given by the vigorous prosecution of an enterprise for building entire works for direct supply, by pumping into the mains without the intervention of a reservoir. The success attending this enterprise, owing to the small first cost of construction and to shrewd management, created competition, the result of which has been to force the adoption of scientific methods and the employment of skilled engineers, and as a consequence there has been great improvement in the types of machinery and in economical working.

The pumping machinery of large cities has also been greatly improved; the duty now required, and uniformly maintained, being at least fifty per cent greater than it was thought possible to obtain twenty years ago, or than is now furnished by the less costly "commercial engines," of which two firms alone have built 242 for 168 towns, with an aggregate pumping capacity of 734 millions of gallons per day.

The construction by Mr. Chesbrough of a submarine tunnel for two miles under Lake Michigan, to furnish water for Chicago, was one of the boldest engineering feats of this century. Its successful completion was followed by the construction of several similar works.

On the Pacific coast the use of unprotected wrought iron pipe for conveying water great distances, and under great pressure, has proved very successful.

During the past ten years the most important work executed has been the enlargement of the gravity supply for Boston, by the construction of a conduit of masonry, in the designing and erection of which the latest and most perfect methods have been followed. The subjects to which particular attention has been paid by engineers during this period have been the efficiency of pumping machinery, the capacity of gathering grounds, the preservation of the purity of the water, and the prevention of waste by consumers.

All American works are constructed for a constant supply, and most of those first built had a capacity far in excess of the then demand, which caused the formation of habits of wastefulness, which it has been found difficult to check when the limit of the capacity was nearly reached.

The magnitude of the interests involved in this branch of engineering may be judged from the fact that there are now in the United States and Canada 569 towns with a public water supply, having a population of about 12,000,000, to whom there are daily distributed over 600,000,000 of gallons of water, through 13,000 miles of pipes, of which about 10,000 miles are of cast iron.

About one-half of these towns are supplied by gravity, many of them, however, having supplemental pumping power, the total capacity of the pumping engines now in use being about 1,900 millions of gallons per day.

Meanwhile improvements in plumbing and house distribution have greatly added to the convenience about our homes, and we now virtually have a spring of cold and another of hot water in almost every room of our city houses to put on tap at will.—*O. Chanute.*

Printing Exhibits.

An interesting exhibition has lately taken place at Agricultural Hall. London, of printing and book machinery, stationery, etc. Among the exhibits the proprietors of the *Daily Chronicle* have on their stand, besides a variety of raw materials and paper stuff, a large roll of paper such as is used in their printing works, but of exceptional dimensions, to show the capacity of paper-making machinery. This roll contains an endless band of paper 110 inches wide and about 5 miles long, and is manufactured on a machine made by Messrs. G. & W. Bertram, of Edinburgh, the rolls of which are 125 inches wide, and it is said to be the largest paper-making machine in the world.

The Lanham Printing Roller Company have on their stand a number of their patent India-rubber rollers, and among them some ink rollers of large size, which have been in daily use on one of the Hoe American printing machines at the London *Daily Telegraph* for over two years, and still appear in excellent condition. These rollers have a solid rubber surface about ¼ inch thick; below this an additional amount of elasticity for special purposes is obtained by casting thin iron rods, about ¼ inch in diameter, at about $\frac{1}{16}$ inch pitch all round into the rubber, and drawing them afterward, leaving holes through the length of roller. The total India-rubber thickness of these rollers is about ⅝ inch, and this shell is fixed over an inner core. To insure perfectly true running, the rollers are carefully turned, and this operation can be repeated should their surface become worn. This, however, appears to be necessary only after very hard wear, and though the rubber rollers are no doubt expensive in first cost, they repay themselves by their reliability and durability.

Messrs. Waterlow & Sons, of London Wall, show a large group of miscellaneous exhibits, among others a stylographic pen, an American device recently introduced into England. It is an admirable specimen of workmanship, and is very ingeniously designed. The handle of the pen is also the ink reservoir, but it contains besides, a hollow stem projecting beyond the lower end of the handle into the cover which terminates in the writing point. The upper end of the stem is open to the air, but is closed with a screw cap that covers a small hole admitting air into the stem. To the lower end of the latter a light spiral gold spring is attached, carrying at its outer end a fine iridium-tipped needle point. This needle is protected by the cover which screws into the stem, and which terminates in a hollow iridium point, through which the end of the needle projects slightly and plays up and down as the point of the pen is passed over the paper, every slight motion of the point pumping down a small supply of ink, while air enters from the top of the pen down the stem already mentioned, and through a small hole at the foot of the stem. The point is protected by a cap, which is fitted on to the top of the handle when the pen is in use. These pens, says *Engineering*, are all of American manufacture, and we doubt whether it would be possible in this country to produce so well-finished a combination of vulcanite and metal.

Chemical Manufactures in Philadelphia.

One of the great industries of Philadelphia is the manufacture of chemicals, or of articles for the production of which chemical processes are necessary. Many of these take the form of drugs and medicines for the wholesale trade, not including specifics. Others are acids, alkalies, and chemical agents used in other manufactures. White lead and chemical paints are also included. The line of distinction is not easy to define to the general reader, though well recognized in the trade, and it does not include the body of products known as dyes, paints, and medicines, although closely related to them. As so defined, the chemical manufacture in Philadelphia includes, says the *Public Ledger*, about thirty establishments, whose annual product has risen from $6,152,380 in 1870, to $10,000,000 in 1875, and $12,000,000 in 1877, and, as nearly as may now be calculated, about $12,000,000 in value for the year just closed. They give employment to about 2,000 persons—a relatively small number for the values produced—and have attained a position of supremacy in their respective departments which renders them reasonably secure. The drug and medicinal products are the largest, eight or ten establishments producing $8,000,000 in value of quinine, morphia, preparations of iodine, bromine, etc., with other standard pharmaceutical preparations. These are now the basis and body of applied pharmacy in this country, and are likely to increase even more rapidly in the future. On the side of standard medicines used as specifics almost as much more would be added, and the classification would be entirely appropriate as a manufacture. The drug and chemical works insist on the distinction, however, and in a calculation of a total of $12,000,000 production they are not included. They would reach $6,000,000 at least, and under the general name of proprietary medicines, footed a total of $5,490,105 in 1870.

Progress of Railways in Texas.

Ex-Governor John C. Brown, Vice-President of the Texas and Pacific Railway, tells the *World* that the progress of the road is now very rapid. Already the line approaches the Brazos River, and by the end of the current year it will have 150 miles or more of track beyond that point. The region is remarkably fertile, and is rapidly filling up with population. Several other important railway operations are being vigorously forwarded in Texas.

Among these is the extension on the Texas and Houston Central westward from Waco to Eastland City. There it makes a junction with the extension of the Texas and Pacific Railroad Company; the extension of the Gulf, Colorado, and Santa Fé road northward and toward Fort Worth or Dallas; the extension of the transcontinental branch of the Texas and Pacific Company Railway line from Sherman to Whitesboro and thence to Denton; the early extension of the Dallas and Wichita to Denton, to connect with the extension from Sherman. A new line from Dallas toward Sabine Pass is being pushed forward under auspices which promise an early construction of the line, which will be most important to the enterprising and growing city of Dallas, and will be a very important feeder to the two trunk lines which cross each other in that city. This line will connect southeastern Texas with the great West and Northwest, and tapping as it does the vast forests of long-leafed pine and red cypress will transport to the prairie countries the products of these forests, which, while this carriage will be a very large source of profit to the lines over which they are conveyed, will furnish cheap lumber to the region of country west of Dallas, which is very rapidly filling up with population and is one of the most productive agricultural sections in the world. From Austin, the capital of Texas, to San Antonio, the most important city in the southwestern part of the State, the International Railroad is being constructed, and it is believed by many that either that line or the one known as the "Sunset Line" will be pushed rapidly to the border of Texas at Laredo or some other point on the Rio Grande.

There are also a number of narrow gauge roads in various parts of the State being rapidly built; among which may be mentioned one from Corpus Christi which follows up the valleys of the Nueces and the Rio Grande; the east line from Jefferson, which is now extended to Sulphur Springs, and is being pushed rapidly west by the way of Greenville and McKinney; the Texas and St. Louis from Texarakana by way of Tyler and Corsican, in the direction of Waco and beyond. Another and perhaps the longest line of narrow gauge in the State, is the one from Houston, known as the Bremonde road, running northeastwardly in the direction of Marshall and Shreveport. There is another railroad enterprise on foot which has been reorganized and promises an early commencement of work from Dallas to Cleburne among the richest and most populous communities in the State.

The Iron Capacity of the United States.

Speaking of the failure of the Vulcan Iron and Nail Works at Chattanooga, *Capital and Labor*, of England, says: "The failure of one remote mill at the present juncture means, perhaps, very little; but throughout the United States many works are reported unemployed, not because there is no demand, but because *the production of raw iron in the United States is really inadequate if America has any pretensions at all to the ability to supply her own needs in respect to raw material.*" These comments exhibit singular ignorance of the iron industry of the United States. The truth is, the blast furnace capacity of the United States is more than sufficient to supply the demand, as shown by the fact that a great many of them have been idle for six or seven years.

The *Enquirer*, on the other hand, "hits the nail on the head" squarely. In a lengthy editorial, besides other facts, it gives utterance to the following: "The United States have at the present moment a great deal more iron than they can possibly use, and *facilities for producing at any time more iron than they want*—always provided that the consumer does not insist in having supplied to him in any one year as much iron and steel as he can use in two years." This, says the *American Manufacturer*, is an undeniable truth most happily stated. It was this singular greed of consumers that led to the heavy importation of iron during the last ten or twelve months, and not the inability of our manufacturers to supply all the iron the country needed.

Expansion of Glass.

The expansion of glass by heat may be demonstrated as follows: A glass tube of narrow bore and about eighteen inches long is bent round in the shape of a horseshoe, so that the free ends are within a millimeter of one another. Between these ends a coin may be held, being nipped between the ends of the rod and held there by the grasp due to the elasticity of the glass. If now the *outer* portion of the curved part be warmed, the ends open slightly and the coin drops out. This experiment is due to the ingenuity of Mr. Ridout.