served in an herbarium. They resembled more closely the ferns of New Zealand or the Hebrides than the ferns with which we are familiar. Some of these ferns grew to the dignity and beauty of the palm-tree itself. One species was peculiar, having only two leaves at a time. We find sometimes in the coal-beds things looking like enormous brooms, which are tree ferns, with roots sent out to straighten the stems. We also find in the coal formation varieties of pine, the wood of which much resembled our modern pines. It is remarkable that the pine is widely diffused at the present day; and it is not wonderful, therefore, that they should have existed in the carboniferous period. Those pines have features more nearly resembling those of Australia and New Zealand than those of our climate. When wood is buried in the earth and its cells filled with water holding silica or lime in solution, they become filled with stone, and the wood becomes coal; and this is the form in which we find these fossil remains. By removing the mineral we can observe the vegetable structure of the plants, and determine their character. Next to the soil on which we tread, the most valuable substance we have is mineral coal, which is derived from the plants of the carboniferous period. A bed of coal is usually composed of the remains of the trunks and bark of sigillaria trees. Examining coal with a microscope, after proper preparation, we can see the structure of the wood from which the coal was derived. Of eighty-one distinct seams of coal in Nova Scotia, every one but two or three had sigillaria, either in the coal or immediately above or beneath it. The top of a coal seam is merely the debris of the last forest that grew on this swamp where the coal was produced. Great Britain annually consumes 100,000,000 tuns of coal, and we know of nothing that will supply its place. The consumption of coal in America is already equal to the labor of 150,000,000 horses, and our coal beds are as yet hardly opened. All this power is extracted from the sunbeams of the paleozoic period. (Applause.) What did these magnificent forests grow for? There seem to have been no higher animals to enjoy them. We know of no birds that lived among their branches. We know of a few insignificant reptiles that crawled beneath them, but we know of nothing higher in that age. What were they created for? For two great purposes. First, to purify the atmosphere so that it might be made suitable for the higher animals that were to live in a future geologic period; and that very process of purifying the atmosphere was made the means of laying up those enormous stores of fossil fuel upon which so much of our modern civilization is based. See how grand are the economies of nature, preparing far back in geologic periods before man existed, for the existence of the present state of the arts in the world. Next to coal in its value comes iron; and although we are not so dependent upon the coal formation for iron as we are for coal, still we get an immense quantity of iron from the carboniferous rocks, accumulated by the agency of these very plants; for as they went to decay, and were converted into coal, they helped to gather together the particles of iron out of the clays and sands, and to store them up for us in iron ore. Therefore we owe to the growth of those old forests not only our coal but a large portion of our iron. And whether we look to the value of the coal in boiling the teakettle, of which Prof. Silliman spoke to you in the last lecture, or to the use of the iron which makes our iron horse, and the steam engine of our factories, we owe it all to the primeval plants, or rather the Maker and Creator of these old plants. Now let me trace these plants a little further back than the period of the coal formation. If we go back from the carboniferous rocks to the Devonian, we shall find a different flora, which no doubt helped to purify the air, and prepare the world for the carboniferous flora. We have in Canada a bed of coal two or three inches thick, belonging to that epoch, and it is the only one I know in America. In this drawing, some of the plants of that period are represented; and here you find the sigillaria, the lepidodendron, the calamites, the pines, etc., as in the later period; so that you see that the Devonian flora was really not very different from that of the carboniferous period. The species are mostly different but the generic forms are the same. As a whole the Devonian flora may be characterized as less massive and magnificent, more delicate and slender in its proportions; not less beautiful but less useful perhaps in the accumulation for us of vast stores of fuel. If we go down below the Devonian rocks into the Silurian, we find a few plants; but in the lower Silurian formation we hardly find any traces of plants. Nearly all the rocks known to us of that age were marine rocks. Prof. D. was not hopeless of the eozoic period even. We have as yet found no plants there; but we have found carbon. We have found plumbago; and even in later formations the remains of plants have sometimes been converted into black-lead in the eozoic strata, occurring in beds, so as much to resemble the remains of plants. They have been sea plants. If they were land plants we may guess what they were—anophytes and thallophytes, gigantic mosses and gigantic lichens. If we were to walk among those ancient forests of mosses, if they really did exist, we should be in a world something like what this would appear to an insect creeping upon the mosses of our woods. I have given you but a faint outline of a great subject, on which treatises might be and have been written, which would afford the material for a course of lectures more interesting than a single one can possibly be. The chief interest of the subject, no doubt, is to the botanist and geologist. The vegetable kingdom now is most beautiful and most varied, especially when we look at it as presenting forms of plants adapted to every climate and every situation upon earth, all of them finding their proper place and their own due season. But the subject before us carries us back into geologic times, and shows us a plan too large to be realized on one earth.

The plan of the Creator was so vast that the whole surface of the earth was not big enough to hold it. It required a series of earths, one after the other, to develop it, just as it has required a series of ages to develop the history of the human race. We have in these old plants something that adds enormously to the variety of the vegetable kingdom; something that shows us how small is our own knowledge, and how great and capable of extension is the plan of the vegetable kingdom. And when we consider further that we know of these fossil plants only what their remnants have taught us, it affords a widening field of wonder and of thought. As it is more interesting to the botanist to go out and collect plants for himself than to study them in the class books, so this subject is of the deepest interest to those who will examine the primeval flora and the coal formations; who will split open the rocks and see the forms that no one ever saw before, and perhaps make discoveries of facts which the world never knew before concerning that remote period of time. I must plead guilty as a fossil botanist—I mean a botanist studying fossils [laughter]—to having the deepest interest in this subject. And it arises in part from the very fact that different names are sometimes given to the same plant—as the tree is called sigillaria, the root stigmaria, and the nut still another name; and it requires much observation and study to discover and to show that these different names all belong to what was really one and the same plant. As our knowledge increases we may be able to dispense with many of these old names, which is more than can be said for modern botany. What would we have been without these old plants, without this great provision made for us in primitive times before man existed upon the earth? These plants form a part of the same plan to which we belong, and undoubtedly that plan existed at the time these old paleozoic plants grew. And now, I may say, even in this Christmas time, as we gather around the hearth, although our coal fire does not burn, and cackle and blaze like the old yew log of our ancestors, yet the trunks of our old sigillaria, burning upon our hearths to-night, send forth a quiet, kindly look, befitting their great age and long burial in the earth. And the happy hearts that gather around the Christmas fireside may thank God that we have had these great stores prepared for us in the times of old, and that we have hearts and minds fitted to enter somewhat into that great plan which stored them up, and for the enjoyment in a measure, even of the beauty of the plants that lived so long ago.

THE EVOLUTION OF THE NORTH AMERICAN CONTINENT---LECTURE BY PROFESSOR HALL.

Reported for the Scientific American.

The above was the subject of a lecture by Professor James Hall, State Geologist of New York State, before the American Institute at Steinway Hall, New York City. The lecturer was introduced by Judge Daly, who referred to the interesting character of the preceding lecture, delivered, as he said by a distinguished Canadian geologist. We shall to-night have the pleasure of listening to a distinguished geologist of our own State, whose reputation, however, is not limited to our own state or the United States. His reputation will be perpetuated by that noble monument, the Natural History of New York, published under his scientific supervision, and of which more than one fourth is the work of the speaker who is about to address us. It is not too much to say that this great work is unequaled by any similar work in existence not comprising a greater area of the earth's surface.

In reply to the complimentary introduction of Judge Daly, Professor Hall said: I am unprepared to say a word in response to the complimentary introduction of your president, but I will say as an adopted citizen of the State of New York, that the natural history of the State is a monument of which, in succeeding generations, every man, woman, and child will have reason to be proud. It has been carried on many years, amid many conflicting circumstances. For the humble part I have had in the work, I have had many pleasures, many griefs and sore trials. But when these are all past, those that follow will reap the benefit of a work that has developed more of natural science than any other American work; which was, in fact the earliest development of natural science upon the American continent

Professor Hall then proceeded to the discussion of the topic of the lecture, the evolution of the North American continent. The lecturer made such frequent references to diagrams upon the blackboard and to charts, that it is impossible to give in a printed report, without diagrams, the arguments by which he sustained his propositions. We shall therefore limit ourselves to an outline of the lecture, giving as far as possible the order in which the continent was evolved as stated by the speaker.

A period existed, ages upon ages ago, when the surface of the earth was entirely covered with water. Under this universal ocean the solid nucleus existed, and by gradual cooling of the earth's crust or by other causes, upheavals took place. These upheavals occurred first at the northern portion of the globe, and extended until a portion of dry land of the so called granitic formation extended down as far as Nova Scotia—at that period an island—and to the great lakes, and westward nearly to the Rocky Mountains. The whole of the continent remaining is formed of sedimentary deposits from the currents which existed in the ocean then as now, layer upon layer of different periods and characters, many of which are from thirty to forty thousand feet in thickness.

Upon every portion of the surface of the earth, we have mountain chains, plains, and valleys; and we have rocks, loose materials, sand, pebbles, gravel, and other materials of that kind, which are distributed over the surface. These are distributed, not regularly, but according to certain laws, which have prevailed in all geologic time. This pebble, for example, which I have before me, has at one time been an angular fragment of rock, broken from a rock which had itself been, at a still earlier time, a loose mass of sand. It has been consolidated. It has become rock. It has again become broken, and these pebbles have been triturated by the motion of the water, the action of the sea, or of rivers and streams, until they have been rounded, the corners worn off, the finer materials being gradually worn away and disappearing, being reduced by the water to an impalpable condition beyond our reach. The harder particles of material like this makes the sand which strews the sea beaches every where. The sand was not from the breaking down of sand stone, but from the breaking down of materials containing sand. While the finer and more impalpable portions have been widely separated, the harder portions, which are a silicious sand, remain to make sea beaches and river beaches. In this respect nature is constantly active. There is no moment of time when this process, this degradation of the surface of the globe is not going on. During every shower, or if you will go back to the first of all this, the evaporation of water by the action of the sun's rays, in the ocean and upon the surface of the earth, lifting it into the atmosphere and precipitating it again upon the surface, transfers the loose materials into the smaller streams, thence into rivers, and thence into the ocean where they are spread out evenly from the facility of their transportation by currents, the coarser materials being first deposited, and then the finer. And the action of the frost annually prepares these materials for the subsequent action of the rain. The water percolating into the crevices of the rocks, freezes, and by its expansion in freezing separates them, until, year by year, more and more of the rocky mass is broken down, and the material prepared to be transported by the rain storms into the ocean.

The continent has been produced step by step during several geological formations; it has never been elevated above the ocean as an entire continent; it has been produced from sediments which have been made by the distribution of materials from pre-existing continents, pre-existing materials lying above the surface of the water. In the northern portion we find the earliest continent, and the breaking down of its materials has given us the silurian, devonian, and carboniferous formations. Constantly have the materials of the land, during all the period subsequent to the carboniferous, been carried westwardly and southwardly, and spread over that portion of our continent. And then, subsequent to this, all this portion of our continent has been elevated. The North American Continent, so far as it is known, although there have been numerous minor oscillations, has had three great phases: First, that in which this portion of the continent alone was above the sea (indicating the northern portion upon the chart); second, that in which the continent extended southward to this second line; and, third, that in which the whole of the western and southern portions have risen above the sea. In each of these epochs there have been distinctly marked the characteristic conditions of ocean and of dry land, indicated by fossils in immense numbers; so that we are able to trace step by step, in each one of these geological formations, each thousands of feet in thickness, not only the characteristic fossils of each successive bed, but we can easily subdivide them. So that in this portion, from the base of the silurian to the devonian, we recognize 20 or 30 different epochs, each marked by its characteristic fossils, with its fauna and its flora as distinct as upon the shores of the country at the present time. Taking the shores of the United States at the present time, and observing the number of animals living along the coast, we have that repeated some 20 or 30 times in this one epoch; each of these having been superseded by and given place to another, and so on in succession, during the silurian period. When we consider that these various animals have lived and died, that each has occupied its place for successive generations, for we do not know how long a time, when we consider that this country has been covered entirely by subsequent deposits, and other creations have taken their place, and so on, while accumulations hundreds of feet thick have been spread over them, when we remember that hundreds, and even thousands of these animals have lived and died, perhaps in each of those 20 or 30 subdivisions of the time, and thus on fauna after fauna, and flora after flora, through all these epochs, you have at last an incomprehensible number of generations of animals, a result which could only have been reached by a process carried on for an infinitely long period of time. One point which I have endeavored to impress upon you is that while this has been going on, there has been, so far as our own continent is concerned, a constant evolution of dry land. If we begin at the latest period, and go backward through these periods, you have in them all the distinction of ocean and dry land, the latest land being formed from the sediment distributed by the ocean, until at last we trace back the continent to the time when it was included within this area (indicating the northern portion). But we have nothing thus far of the original crust of the globe—nothing which geology can tell us of a nucleus which has been of melted matter. Still further north is a portion of the continent we know very little of. It is possible that this may be of older rocks. We know that there are older rocks that are stratified rocks, not only on this continent but on the continent of Europe; but we have no evidence that there were ever any rocks earlier than the sedimentary rocks. The granite of the Rocky Mountains is as much stratified as that of Northern New York; and wherever these strata are found we know that they have been deposited by water. Even in the old Laurentian rocks, those granite rocks of the North, there are same portions of the rocks containing pebbles derived from pre-existing stratified rocks. When we know that in the old sienite of the northern portion of this country we have pebbles which are stratified, like that which I hold in my hand, showing the remains of sediment, particles of sand transported to another place, and there becoming rock previous to the deposit of the materials which have been converted into gneiss, sienite, and granite, we know that there must have been

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other stratified rocks older than our granites, previously existing and broken down, pebbles from which were transported and imbedded in the sediments now constituting those oldest known rocks. So that we go back not only as far as we can absolutely see the rocks, but still farther, and we demonstrate that there are still earlier periods, when there were deposits of rocks yet to be discovered by geology, earlier than the earliest rocks we know, lower than the lowest rocks we know; and these being stratified rocks, we may say that water from the beginning of our knowledge has existed upon the surface of the globe. We have, then, no knowledge whatever of the primary nucleus. We see that by the action of water materials have been transported from one part of the surface of the globe to another, covering the former ocean beds with enormous accumulations of sediment; which, after a time, by this change in the relation of the parts, and by the increase of temperature beneath the landed part, have risen up and become, step by step, islands or continents. It is by this process that, age after age, the American continent has assumed its present form. But I desire to impress upon you this one truth; that we have, in our geological investigation, succeeded in going back one step beyond the existence of water and stratification —one step toward this original and so-called primary nucleus, a nucleus of molten matter. This original nucleus that has been talked about in geology, has produced no effect upon the surface of the earth; neither upon its mountain chains or any other of the great features of the continent. Neither have these features been produced by it or by materials derived from it. I have shown that in the form of the continent the materials composing it have been derived from the breaking down of pre-existing materials transported and deposited along certain lines, or spread out in mid-ocean and there accumulating uniformly. The inequalities upon the surface of the country are not due to any special action along these lines of elevation. Those mountain ranges, whether the Rocky Mountains of the West, the Appalachian chain of the East, or any other chain of mountains, so far as we know, are not due to any action or any forces along those lines, but only to the greater currents in the bed of the ocean near those lines, as I have shown you regarding the Appalachian chain. Everywhere the same law has prevailed. The transporting power of the ocean has deposited in the line of its currents larger quantities of material. The elevation has been a continental one, and not the elevation of a mountain or of a chain of mountains. The elevation of the eastern portion of the North American continent has nothing to do with the mountain chains constituting a portion of the continental elevation. Going back, then, step by step, from the more recent to the earliest times in relation to which we have any evidence whatever, we have no proof that the action of the interior of our globe has produced any of the great features of the globe. This idea of a great primary nucleus is only theoretical. It has not in it anything tangible. The earliest rocks of which we have any knowledge were deposited by the ocean under conditions similar to those which now exist. The conditions of the ocean currents are the same now that they have been from the earliest time. From the earliest history of the American continent, from the earliest history of any other, we know that the ocean currents have prevailed as they now prevail, moving northward and southward; and here, at least, the transporting power has generally been from the north toward the south and west; and we have abundant evidence that all the materials composing our continent have been derived in that way from the transporting agency of currents of water alone.

The Rabbit Plague of Australia.

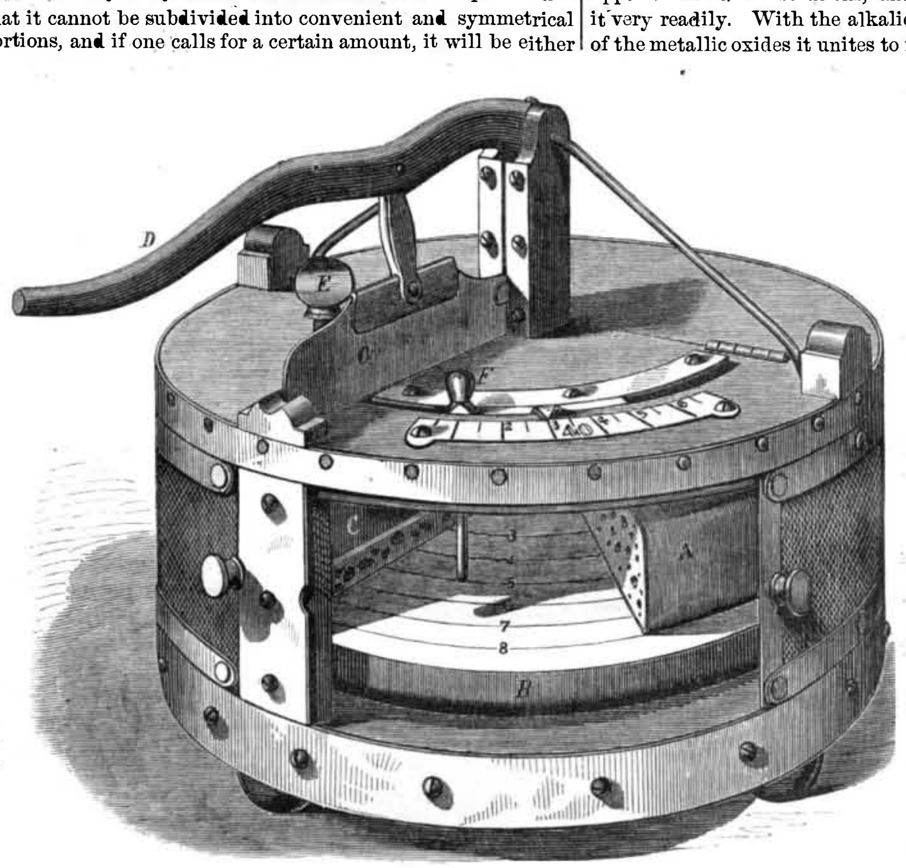
The rabbit originally brought from England into Australia is now threatening to become a plague of almost Egyptian magnitude in the distant and thinly populated plains. Only a year or two ago not a rabbit was to be seen save as a curiosity in a hutch; but the wild rabbit, most prolific of importations, has so increased in numbers in some parts of the country that it threatens to starve the very sheep out of their runs. Mr. William Robertson, a large landholder and squatter near Colac, has been put to a cost of four or five thousand pounds in the, as yet, abortive effort to exterminate these now considered vermin, and he estimates that it will cost him £10,000, in wages to trappers and killers before he will have achieved any marked success in abating the nuisance. "At the same time they are spreading more or less in all parts of the country, and I have seen them scampering about even in gardens near Melbourne. As food they greatly affect some of the most beautiful of our flowers—nothing, however coming amiss to them—and they are, therefore, becoming the terror of horticulturists. Now that the plague is on us in full force we can, of course, all very easily account for what no one foresaw. Any equally prolific animal, equally well circumstanced as to climate and feed, must become equally numerous in any country as thinly populated as ours. In England the wild rabbit meets with many destroyers; here there are very few. In England rabbit killing is sport; in Australia it is generally work to be paid for. Dead rabbits are daily hawked about the streets at six pence each, and the market is always glutted."

The Sword-Fish.

A marine insurance case is now being tried in England, which involves a serious question as to the power of a sword fish to inflict damage and endanger lives. The ship *Dreadnought*, an East Indiaman, was recently taken into port leaking badly from a small hole below the water line. Her owners demanded the cost of repairs from the insurance company, claiming that the hole was made by a sword fish. If it was not made by some external force, nothing can be collected. The insurance company answers that there is no instance on record in which a sword fish, having punctured the side of a vessel, has escaped without leaving his sword in the hole. The plaintiffs prove that a few hours before the discovery of the leak, the crew had seen a very large sword fish in the water, and had tried to capture it with lines and hooks. Prof. Owen delivered a scientific lecture on the sword fish from the witness-box during the trial. The sword of this fish, is the hardest bony material known; it has a sheath harder than the enamel of human teeth; within his personal experience the sides of two ships have been pierced by this submarine stiletto; the blade was usually left in the wound, while the hilt, or in other words. the fish itself, broke away. He quoted examples of this wonderful weapon being driven through fourteen inches of copper sheathing, felt, deal, and oak; his evidence simply demonstrated the enormous power of this formidable monster. In the case before him, Prof. Owen admitted that the fish, having passed its dagger through only three inches of wood, might possibly have withdrawn it. A precisely similar illustration was presented to him several years ago, except that the sword was broken, and actually stopped a leak which might otherwise have been fatal to the ship.

Improved Safe for Preserving Cheese.

Safes for protecting cheeses, when cut, from the attacks of flies, are common enough; they are used in every well managed grocery; but their contents are often mutilated in so miserable a style that the satisfaction in purchasing a bit of cheese is alloyed by the consideration that its shape is such that it cannot be subdivided into convenient and symmetrical portions, and if one calls for a certain amount, it will be either



BULGIN'S IMPROVED CHEESE SAFE AND CHEESE CUTTER.

short or excessive in weight. This is an annoyance to the purchaser and a loss to the seller. The object of the device shown in the engraving is to obviate these difficulties.

The safe is in general construction similar to those in common use, the sides being covered with wire gauze. But the cheese is received on a revolving circular platform, one half of the cover and side opening to admit it in the usual manner. The face of the platform is divided into concentric circles numbered to show their relations, or the relative weights of the cheeses the platform receives. The cheese, A, being placed on the platform, B, concentric with one of the circular lines, it is cut by means of the knife, C, worked by the lever, D. The thumb screw, E, has a flat revolving head on its lower end that engages with the top of the cheese by which it may be held in position while being cut, and be prevented from rising when the knife is withdrawn. The pin, F, passes through the cover or top of the safe, the knob being used to slide a segmental strip having a pointer that designates on a fixed and graded segment the proportionate weight or amount of the cheese to be cut, the downward projecting portion of the pin coming in contact with the cut face of the cheese, and serving as an additional guide to the amount to be cut. The front of the safe is composed of two sliding doors seen open in the engraving.

Patented July 7, 1868 to Edwin G. Bulgin. Letters of inquiry may be addressed to W. G. Bulgin, Vienna, N. J.

GLASS--ITS COMPOSITION.

The discovery of glass was no doubt in the first instance accidental. Whether credit is given to the statement of Pliny in regard to its origin or not, it is scarcely conceivable that in the manufacture of pottery, and some other arts known from the earliest periods, the materials of which glass is composed should not have come together and have been fused so as to have become glass. His account is that glass was discovered by mariners, who, compelled to seek the shore as a refuge from a severe tempest, discovered glass in the ashes of a fire with which they cooked their food. Whether this event ever happened or not, it is quite certain that it might have happened, as the sand of many beaches, with the ashes of some kinds of fuel would, when fused together inevitably form glass, as will be seen upon a consideration of its composition.

Glass may be composed of various materials, but one is essential to all glass, viz., silica. The other materials may be potash, soda ash, lime, alumina (the oxide of aluminum which with some impurities constitutes the various clays), minium (red oxide of lead, red lead), magnesia, etc., which may be varied in their proportions to suit the quality of the glass required; the purity of the materials, of course, regulating the fineness of the product.

Silica is the oxide of a metal called silicon or silicium. It is found nearly pure in quartz, and is with various coloring matters, the substance of agates, opals, flints, etc. Its purest native form is that of rock crystal, of which beautiful specimens are found in England, Scotland, California, and other parts of the world. These crystals are cut into proper shape for ornaments and lenses for spectacles called pebbles. The latter are considered superior to those made of glass. Sand and sandstone are quartz more or less pure. Glass can be made with quartz and flints pulverized, but sand if sufficiently pure is preferred, as it obviates the expense of pulverizing. Sand to be useful for making clear white glass, should be free from earthy matters and certain metallic oxides. The latter give various colors to glass, and when present to any great extent, unfit the material for anything but the coarser varieties of work, as green bottle glass, etc.

Silica has been shown by chemists to be an acid. As it is insoluble in water however, its acid properties do not readily appear. Alkaline solutions, and hydrofluoric acid, dissolve it very readily. With the alkalies, alkaline earths, and some of the metallic oxides it unites to form salts called silicates, for the most part insoluble in water, or in acids, except hydro-fluoric acid, but soluble in strong alkaline solutions. Thus a strong solution of potash will eventually dissolve through an ordinary glass bottle if kept in it long enough.

Glass is a fused mixture of some of the silicates of potash, soda, lime, magnesia, alumina, and lead. These silicates might be formed separately and fused together afterwards, but the requisite homogeneousness is better obtained by mixing in the proper proportions the materials of which they are composed and melting them together, the combinations taking place during the "melt."

The process of melting is performed in large pots made of refractory clay, placed in a conical furnace with a chimney at the apex. The heat is carried to a very high point to insure perfect combination and fusion, and is continued from ten to thirty hours, according to the kind of glass to be made. The heat is kept up as constantly as possible day and night, as much loss would accrue by allowing the furnaces to cool and re-heating them. In order that the temperature of the furnace shall be kept as even as possible the coal is added lump by lump, being thrown in through a small hole in the side of the furnace by a man who performs only that special service. Each furnace contains a number of these pots with an aperture to correspond with each, at proper intervals around the cone. From each of these apertures the fused glass is taken as wanted and manipulated so as to form the various articles of glassware in use. These manipulations, comprising what is technically known as "glass-blowing," will form the subject of a future article.

Dr. Ure makes the following classes of glass, based upon their chemical composition:

1. Soluble glass, sometimes called waterglass—a simple silicate of potash or soda, or both of these alkalies—so called because it is soluble in water.

2. Bohemian or crown glass; silicates of potash and lime.

3. Common window and mirror glass; silicates of soda and lime; sometimes also of potash.

4 Bottle glass; silicates of soda, lime, alumina, and iron.

5. Ordinary crystal glass; silicates of potash and lead.

6. Flint glass—silicates of potash and lead with larger proportion of lead than crystal glass—so called because it was made originally with powdered flint.

7. Strass; same as preceding with still more lead.

8. Enamel; silicate and stannate or antimoniate of potash, or soda or lead. A stannate of potash or soda is a compound of stannic acid, formed by the combination of oxygen and tin, with either potash or soda. An antimoniate of potash or soda is a compound of antimonic acid, formed by the chemical union of antimony, and oxygen with one or the other of those alkalies.

The quality of glass depends very much upon the method of manufacture as well as the materials employed. In particular the process of annealing is a very important one, as if this be neglected or imperfectly done, articles of glass are so brittle as to be almost worthless for any practical use. The manner in which annealing is performed will be hereafter described. To give the proportions used in various manufactories for the different kinds of glass would occupy too much

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