comparisons of this nature, and also in indicating the comparative density of population to that of the facilities for its conveyance by rail.

THE CRINOIDS OF CRAWFORDSVILLE.

BY H. C. HOVEY.

The rocks of Indiana are generally hidden by heavy drift and lacustral deposits. Their nature and contents are ascertained by the exposure of strata along the line of streams, and more recently by quarries, mines, and other artificial excavations. Of the latter there were few in those early days when Prof. E. O. Hovey—for whom, in behalf of science as well as from filial regard, a place is claimed among the pioneer geologists of the West—began to explore the resources of that region. The extensive cabinet of Wabash College is a memorial of his diligence; but those who admire its specimens can hardly realize the weary rambles on foot and hazardous voyages by raft or canoe by means of which many of them were secured.

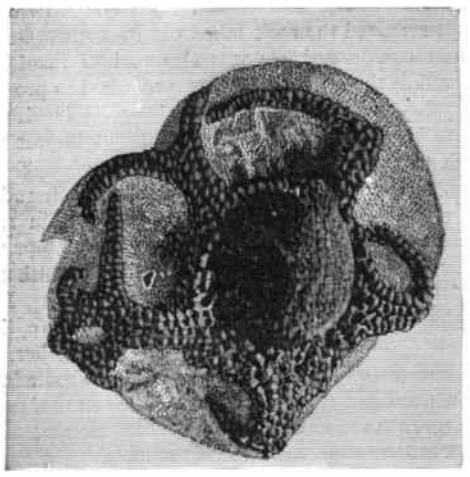
Here and there, along Sugar Creek, as it cuts its way through the woodlands and wheat fields of Montgomery county, my father discovered, as early as 1836, banks made up of rings and stems mingled with shells and geodes. Public attention was first called to these singular deposits in Owen's preliminary geological report (1838), on account of their economic value as material for the manufacture of lime. He merely says: "Four miles below Crawfordsville, at the mouth of Aufield's Creek, a stratum, some four to eight feet thick, of encrinital limestone is exposed." The next notice taken of the locality is in Lawrence's manual of the "Geological Formations of the Western States" (Boston, 1843), in which he speaks of it as exceedingly rich in encrinites. "Here," he says, "the finest specimens in the country are obtained, both on account of their size and beauty." I doubt if either of these gentlemen did more than make a flying visit to those crinoid banks, or saw anything better than the rings and stems referred to above.

Organic remains, such as those now described, both interested and puzzled scientific men long before their true nature was discovered. Three hundred years ago curiosity-hunters in Europe found pebbles impressed with star-shaped figures, and called them "trochites." At first, they were regarded with mysterious awe; and it was doubted whether they were crystals, petrefactions, or elfin charms. Certain flower-like impressions were afterward found on the rocks, which were called "encrinites," or stone lilies. The long stems and feathery corona of these mimic blossoms deceived even the great botanist, Linnæus, who did not detect their animal nature. In A. D. 1755, a "marine palm" was found near the island of Martinique, which was described as such in the tenth edition of "Systema Naturæ," under the name of the *Pentacrinus asterias*. This is now regarded as the typical crinoid.

Cuvier saw the truth that had escaped others, namely, that the Pentacrinus, instead of being a plant, was an animal, "a star fish with a stem;" and that the encrinite was its fossil representative, of which the trochites were only fragments. At a still later day the name "crinoidea" was given, by J. S. Miller, to include the entire order. In common parlance at the West the term encrinites has been given to the fragmentary stems, while that of crinoid has been reserved for the flower-like head growing at the upper end of the stem. For reasons that will appear more fully in the course of this article, we know that, where the former are most abundant the latter are rare, and indeed they are now sought in an entirely different stratum.

In the summer of 1842, a New York collector advertised for encrinites, offering to pay $5 a bushel for them on delivery. What a chance for a boy nine years old to earn pocket money! I forwarded a bushel of the stems at once, and told him he could have more at the same rate; but he sent word that the market was supplied! While filling this order I picked up a pebble wholly unlike anything previously found in the region, and prudently retained it for my juvenile cabinet. It was covered with warty protuberances, and hence was identified by the rustics as a "petrified toad," by the same process of guesswork that led them to describe the stems as petrified snakes, and the rings as Indian beads. But my specimen was really a weather-beaten *Actinocrinus*, and was probably the first true crinoid ever found in the Crawfordsville banks, whence thousands have since gone to adorn public and private cabinets in this country and in Europe. The locality where it was obtained is now called Corey's Bluff, and is about six miles above the spot mentioned by Owen. Other crinoid banks were also explored—at Remley's Ford, Island Ford, Indian Ford, and on Walnut Fork, Black Creek, and other tributaries of Sugar Creek. By diligent search, additional crinoids were found, and of greatly diversified peculiarities. They are referable to what is now known as the Keokuk group, forming part of the broad belt of sub-carboniferous rocks that sweeps entirely through the State from the Ohio River to Lake Michigan. To the early geologists, however, who cautiously felt their way along the path of science, it was simply known as "Formation No. 3," and its fossils likewise were for the most part merely numbered, except in cases where well ascertained distinctions warranted an attempt at classification by names. My father published several articles bringing the crinoid banks of Indiana to the notice of the scientific world; but he left the task of describing new genera and species to those whom he regarded as more experienced palæontologists.

As recently as 1848, the only books in existence devoted exclusively to the subject of crinoids were the monographs of Miller and Austin, treating wholly of those that had been found in Europe. Numerous papers on the subject had appeared, however, some of them dating back to the last century; but these were scattered through various scientific works with which Indiana libraries were at that time scantily supplied. New contributions to crinoidal literature have been made since then in profusion, especially in connection with the elegant volumes embodying the results of geological surveys in many of the Western States, until now it is



GONIASTEROIDOCRINUS TUBEROSUS—(Natural Size.)

said that three hundred and eighty naturalists have written on crinoids, and that their productions would fill a library by themselves!

Agassiz, in his "Methods of Study," skillfully and at considerable length, traces the homology of the echinodermata; showing that the star fish, sea urchin, serpent star, sea cucumber, and sea lily (crinoid) are but modifications of one persistent creative idea.

Haeckel exalts the Echinodermata from being, as in the Cuvierian system, a mere class of the Radiata—the lowest sub-kingdom—to an honorable rank as one of the seven chief tribes into which he divides the animal kingdom, and only the third below the Vertebrata. He also arranges the crinoidea in three families, namely, those having arms and stems (brachiata); those that are nut-like (blastoidea); those that resemble little sacs or pouches (cystidea). The Indiana crinoids are mostly brachiata, but the other two families are represented.

The anatomy of the crinoid presents certain remarkable features, to be described as follows:

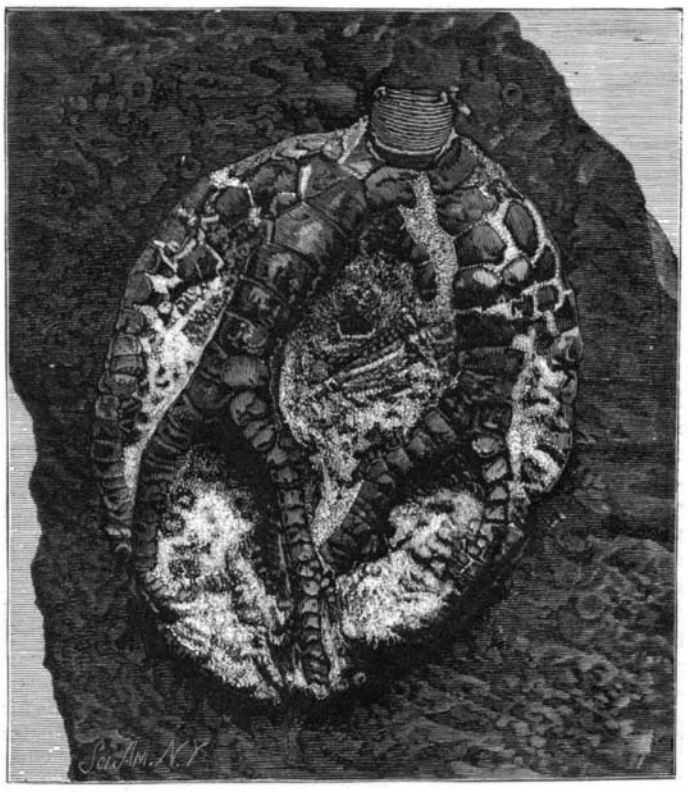


Fig. 2.—ONYCHOCRINUS EXCULPTUS—(Natural Size.)

1. *The Root.*—The comatula, and other free crinoids, have mere tufts of cirri, whereby to grasp sea weeds or any other support, or else to anchor themselves on muddy bottoms. They can free themselves at pleasure and either swim or float away elsewhere. But the fixed crinoids have stout, jointed, branching roots, some of which look like the stumps of diminutive oaks. These may grasp branches of coral, and the stems of other crinoids, or they may spread wide ramifications on the mud of the sea floor. Other roots are formed by a simple enlargement of the lowest ossicle of the stem, cementing it by concentric layers to a ledge of rock, whence the plant-like animal rises amid the waters. There are specimens in the Harvard Museum, in which this is reversed; the roots clinging to lignite, showing that these crinoids, which are from the Tertiary, originally hung down from floating blocks of wood.

2. *The Stem.*—This is a series of flat, calcareous rings, uniting to form a tubular column that rests on the root. The shape often varies, even in a single stem, making the identification of fragments difficult. The cyclindrical form prevails, but many are oval or pentagonal. The canal generally, but not always, conforms to the exterior. The rings are in some specimens extremely thin, while in others they are a quarter of an inch thick. They break with a crystalline fracture. The softer parts, not being capable of petrifaction, have disappeared; but it is supposed that in the living animal the joints were held together by fibers running lengthwise of the stem, and also by an integument. The canal was filled with gelatinous substance. The articulations of the disks usually radiate in fine lines from the canal outward. but in the curiously twisted stem of the *Platycrinus hemisphericus* a ridge coinciding with the long axis of the oval joint takes the place of these lines. This beautiful species has also two spiral rows of tendrils along a portion of its stalk, each joint furnishing a pair. In other varieties the tendrils protrude singly or in pairs, or in whorls of threes, or even fives. I have seen fifty successive rings without a tendril, and then one will shoot out of great relative size, spanning five or six rings at its base. Some stems are smooth, faintly marked cylinders; others are grooved, fluted, bead-like, moniliform, or decorated with spines and knobs. Usually they are broken up into pieces from one to five inches in length. But they often are much longer, and one was measured at Island Ford that was six feet long as it lay on the ledge. They vary in diameter from one thirty-second of an inch to an inch or more. Tablets of encrinital limestone are to be seen where they lie in coils and knots, cemented to the stone, with here and there a head in bass-relief.

3. *The Head.*—Every stem is fairly entitled to a head, but they are seldom found together. This is due partly to the existence of a peculiar split joint, called by Miller a "syzygy," not bound by muscles or fibers, hence easily snapped by a jerk, to free an entangled arm, that is afterward reproduced at leisure. Prof. Verrill states that living crinoids have to be taken with great care, and at once immersed in alcohol, or else they will literally fly all to pieces. This work of destruction is also aided by the natural decay of the membrane covering and holding together the whole body in life; whereupon the hundreds of calcareous plates fall apart. Hence good heads do not abound where the stems are best; but in beds of shale that was once mud, by which the animal was smothered and held while the stems, dismembered, sank down to a lower stratum. This is shown by a section of Corey's Bluff. On a floor of limestone rests a bed of blue shale, twenty-five feet thick, and almost completely made up of encrinite stems. Above this is a layer of gray sandstone, two feet thick, supporting a bed of softer shale than the first. Here the heads abound, being preserved as described. This is about five feet thick. Successive strata of sandstone, comparatively barren of fossils, rise for twenty-five feet, or to the soil. Thus deep and heavy excavations must be made in order to get at the fossiliferous horizon.

Inspection of a well cleaned calyx, or head, shows it to be built up of several series of plates. The lowest are the *basals*, being from two to six calcareous buttons resting on the terminal disk of the stem. Then come one or more circles of *radials* and *interradials*, uniting to form a visceral cup. The uppermost row is suitably beveled to receive the *brachials*, or arm plates. The primary branches are liable to repeated subdivision, until in some species there are from 80 to 100 rays, and the total number of plates exceeds 1,000, besides their fringe of graceful cilia. When the arms are expanded, or entirely removed, the close-fitting ventral plates are seen. The stomach is supported, as it seems from the researches of Meek and Worthen, by a convoluted cylinder, resembling the finest lace. The proboscis, or chimney, is really an excretory tube, rising from the ventral plates, in some cases, till it protrudes beyond the arms.

Austin, Murchison, and others regarded crinoids as predatory creatures, crushing and devouring shell-fish. But observation of living species proves this to be an error. The animal sucks in through channels in its arms, tiny streams holding food in suspension or solution. These are poured into the stomach, sifted perhaps by the net-like apparatus described above; then when all assimilable matter is extracted the exhausted liquid is spurted through the proboscis to such a distance as to prevent its immediate return. The currents thus made drew in young parasitic shells, which they also fed by animalcula. The most common of these in former ages were the *platyceras*, scores of which I have examined without finding any evidence that they either devoured or were devoured by the host that carried them; yet the shell sometimes grew to such a size as to be a troublesome if not a fatal guest. (See Fig. 1.)

The entire number of crinoids secured by us, including purchases, was about 3,000; varying in size from the *Onychocrinus exculptus* (Fig. 2) down to the merest buds and sprays. The best were cleaned for the cabinet; many were disposed of by exchange; the remainder are stored in boxes.

It is estimated that more that 5,000 crinoids in all have

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been found in the vicinity of Crawfordsville by various collectors, among whom should be mentioned Mr. C. Dyer, Mr. F. H. Bradley, and the Coreys. Corey's Bluff is now the property of Prof. D. A. Bassett, whose improved methods, both of quarrying and of cleaning, have gained admirable results. The removal of the incrusted shale is effected by brushes, graded awls, and needles, and requires a degree of skill. Some specimens are so tender as to crumble under the most careful handling; and others are so hardened by silex as to be refractory. But patient manipulation is usually well recompensed.

A complete list, so far as known, of the fossils of the Keokuk group at Crawfordsville, was prepared by my father in the last year of his life, and after due revision was published in the State Geological Report of Indiana for 1875 (pp. 376–381), together with valuable observations by Prof John Collett. From this catalogue it appears that twenty-seven genera and fifty-eight species of crinoids from that locality have been described by Hall, Meek, Worthen, and others, while several new species yet remain inedited.

Crinoids were the first of their class to appear in Paleozoic time. They became more scarce during the Mesozoic and Tertiary ages, until now they have mainly yielded the seas to star-fish, sea-urchins, and other modern echinoderms. It may be that their luxuriant growth in the period before the coal formation was due to water saturated with carbonate of lime and resting under pressure of a heavy atmosphere. That they then grew in shallow water is evident from the relation of the crinoid banks to the coal beds rich in remains of terrestrial vegetation. Only six genera of stalked crinoids are now known to inhabit the whole ocean, and these are found at depths ranging from 2,000 to 15,000 feet! Though eagerly sought for more than a century only twenty specimens were found, until the number was recently increased by deep sea dredging, whose results have been given to the world by Sir Wyville Thomson, in the "Voyage of the Challenger" and "The Depths of the Sea."

It is said that in Agassiz's expedition last summer 300 specimens were taken. Possibly somewhere amid "the abyssal province," including 140,000 square miles, the explored portions of which are to be reckoned only by the square yard, regions may yet be found where these beautiful sea-lilies are as abundant as they were when Indiana lay at the bottom of the sea, and instead of fields of wheat and corn had only crops of coral and crinoids.

NEW INVENTIONS.

An improved attachment for carriages, which furnishes a convenient support for carriages, has been patented by Emma J. Osborne, of Easley, S. C. The invention consists in a slide in the floor of the carriage, at the rear thereof, which slide can be drawn out to carry the baggage, and can be pushed back so as to be out of the way when not in use.

Mr. Martin J. Sunderlin, of Watkins, N. Y., has patented an improved apparatus for cleaning horses. The present invention is an improvement upon apparatus for which letters patent have been allowed to the same inventor, which apparatus consists, essentially, of a brush for cleaning horses, carriages, etc., a flexible pipe supplying water to the brush from an elevated or other source of water supply; and the object of the present improvement is to simplify and cheapen the construction.

An improved rubber bracelet has been patented by Mr. David Stone, of New York city. The object of this invention is to furnish rubber bracelets simple and inxpensive in construction and neat and ornamental in appearance. The invention consists in constructing rubber bracelets with extensions upon the opposite side edges of the band to represent buckles; also, in forming slots in the said extensions, and also in the combination, with the slotted extensions, of the cross bar placed upon the inner side of the band, with its ends projecting through the slots and resting upon the side extensions.

Mr. Abraham Van Winkle, of Newark, N. J., has patented a novel frame for anodes, the object being to prevent the falling apart of the particles or pieces of the anode after it has become disintegrated by the action of the electric current while hanging in the solution without substantially interfering with the exposure of the surfaces of the anode to the solution. The invention consists in combining a frame of wood or other suitable material, with the edges of an anode of cast or rolled metal.

Mr. Daniel Dunscomb, of New York city, has patented an improved cover designed especially for dredging boxes or for boxes intended to hold powders of any kind. It consists in a cover, preferably metallic, having a central aperture, and of a perforated metallic cap having a downward projecting notched elastic rim. This cap is removably fitted into the aperture of the cover.

Mr. Nathaniel Pyles, of 43 Canal street, Chicago, Ill., has patented an improved carpet and floor dust receiver. The object of this invention is to provide a dust pan or receiver that may be pushed along in front of the person sweeping by the broom as the carpet is being swept in the usual way, to receive all of the dust and dirt raised or swept up by the broom and carry it along until the entire floor has been swept.

An improved plow has been patented by Messrs Peter S. Swartz and Alexander Arnot, of Lexington, Mich. The object of this invention is to provide a double-ended plow so arranged that its movement can be easily reversed at the end of the furrow. The invention consists of a double-ended plow having the beam head, to which the beam and the handles are attached, pivoted to a plate on the upper edge of the land side in such a manner that the motion of the plow can be reversed by simply turning the handle and beam around the pivot, the body of the plow not being changed in its position.

AMERICAN INDUSTRIES.—No. 45.

THE MANUFACTURE OF AIR COMPRESSORS, STEAM ENGINES, AND PUMPS.—THE NORWALK IRON WORKS COMPANY.

A great deal of the success of some of the most difficult of modern engineering work has been due to the improved methods of applying compressed air to transmit the power required. By no other means at present known can the power obtained from steam or water be more conveniently stored and transmitted for use at long distances, so as to be readily applicable for all purposes. It was the expansive elasticity of air, condensed by the power furnished by a mountain stream, that worked the distant boring machines and removed the rock taken out of the St. Gothard tunnel; and compressed air was also said to furnish the lungs as well as the heart of the force required to prosecute this enterprise, as without the ventilation thus furnished it would have been not only tedious but almost impossible to make such an extensive excavation.

Probably one of the most economical, compact, and serviceable of the air compressors introduced within recent years is that made by the Norwalk Iron Works Company, at South Norwalk, Conn., whose establishment furnishes the subject of the first page illustrations of this paper. It is a steam engine and air compressor combined, the steam cylinder and two air cylinders being in line with each other, each stroke of the piston rod condensing air in the cylinders in both its outward and inward motions. One of the air cylinders is larger than the other, and here the air receives its first compression, after which it is forced into the smaller cylinder to receive the heavier compression. The heat developed by compression in this way is not so great as when the whole work is done in one cylinder, the air having time to cool in the intermediate pipes between the cylinders and while in contact with a very large cooling surface in passing under the water jackets of the two cylinders. The cylinders are strongly fastened to a long, heavy frame, which is bolted to a solid foundation, and two heavy fly-wheels give evenness and steadiness to the motion, a governor regulating the speed. By this arrangement of a compound compressor the power developed in the steam cylinder is so evenly applied in the reciprocating parts that the most economical speed of piston can be obtained. The air valves are placed in the cylinder heads, and the water for cooling the air while being compressed circulates around the cylinders in a jacket.

In the manufacture of steam pumps the Norwalk Iron Works have for many years held a leading position, and were in a measure the pioneers in the introduction of many of the most important modern improvements. They obtained the control of the "Earle" patents, and made many important improvements simplifying the mechanism, and increasing the efficiency and durability of the pump. To secure the latter point they obtained a patent for a changeable cylinder lining, in which the valve seats are of gun metal, fitted to gauges, so they can be quickly removed when worn out and new ones put in their places. This work can be quickly done without disturbing the pipe connections, and without material stoppage of any of the operations for which the steady working of the pump may be important. The composition lining is an important feature where a pump is to be used for corrosive liquids, since it resists corrosion much better than iron, and, the parts being interchangeable, it is but a short job at any time to make the pump practically "as good as new," and at small cost. At the time the company introduced these improvements they constructed new patterns throughout, giving their latest style the distinguishing title of "the Norwalk steam pump." These pumps are used for every variety of work, for boiler feeding, for fire purposes, for steamboats and factories, for oils, acids, sugar, liquor, chemicals, etc. Every pump is tested before it leaves the establishment. The department devoted to this work is shown in our illustration to the right at the top of the page.

The hoisting engine, shown in the engraving, represents one of the latest products of the Norwalk Iron Works Company in this department. It is simple in its parts, built with exceptional strength, and economical in its consumption of fuel in proportion to the power developed. The company also make horizontal stationary engines, several hundred of their manufacture being in use in different parts of the country. They have now running in their own establishment one of 75 horse power, which they built ten years ago, and which has been running ever since. It is almost noiseless in its operation, and the consumption of coal for the power required in the machine-shop and foundry, with that furnished for some other manufacturing operations on the premises, as well as steam for heating in the winter time, does not exceed an average of a ton and a quarter per day.

The general view at the center of the page gives a good idea of the extent of the establishment of the Norwalk Iron Works Company. The main building is 300 feet long by 100 wide, connected with which is an engine and boiler house, and at a distance of a foot is the foundry, 150 by 70 feet. They do business direct with their customers, from their place in South Norwalk, Conn., a siding from the New York and New Haven Railroad running direct to the works.

Going to a Fire.

One of the most exciting sights a stranger can witness in the lower part of New York is the fire department responding to an alarm of fire in the daytime. A representative of the *Fireman's Journal* describes a scene familiar to all our citizens, but one that many of our readers have probably never witnessed. We chanced to be in Broadway a day or two since, says the writer, when the street was crowded with vehicles of all kinds, and the sidewalks with a regular procession of pedestrians. Suddenly the gong of an approaching steamer sounded with its sharp, sudden, and continuous jingle; there was a rush of teams to clear the center of the street, and a rush of policemen to aid the drivers in getting their vehicles against the curb; then came a fireman running for dear life, shouting "clear the road," and right behind him came the steamer, the horses on the gallop, and a cloud of smoke issuing from the smoke stack; a moment, and she was gone. Then came a hook and ladder truck, with sounding gong, horses on the jump, and the members of the company clinging to their precarious perches on top. Next came the Salvage Corps, gong sounding, horses running, and the men urging them as if their lives depended on their speed. It was an exciting event, lasting but a moment, but quickening to the pulse of the laziest on-looker. Thousands of persons had stopped to catch a glimpse of the passing firemen, and for over a mile Broadway was jammed with vehicles and pedestrians, all of whom had turned out to make room for the firemen, on whose speed might depend the property and lives of some of our citizens. To a stranger the sight must have been a thrilling one, and impressed him with the efficiency of our fire department. We know that to our soldiers the heavy rumble of the apparatus seemed like the movement of artillery to the front and to presage an impending battle. And so it was a battle—a fight between the trained firemen and an enemy as old as the earth or the heavens, and one that has scourged mankind since time was.

Improved Telephone Call.

The *Boston Advertiser* describes an improved telephone call signal, which is about to be introduced in that city It is not of application where a subscriber has a private wire, but is for use in the smaller cities where several subscribers are on the same wire, and, when one is called, all hear the bell, and each must have his separate call. It is a device by which only the person desired may be called and so, without any particular style of call, as at present, he knows whenever he hears the bell that it is for him The apparatus is something like this: At the central office is a clock which regulates a clock in the office of each subscriber on the circuit, so that they all run in exactly the same time. This is done by setting the subscribers' clocks, so that whatever variation they have will make them faster than the central clock, and by a current of electricity they are made correct once in every minute. Upon the faces of these clocks and the central one is a dial around the second hand, marked off into as many divisions as there are subscribers on the wire. Whenever the second hand is in the division marked "1," the subscriber who has that number may be called and no other one will hear the bell. The same is true of No. 2 and so on around the circle. Suppose there are eight subscribers on the wire, each would have seven and a half seconds every minute in which he could be called—deducting a brief interval of silence at the beginning, which is given in order that the calls may not be mixed. As two seconds is ample time for calling a person, it will be seen that there is a good margin allowed. The apparatus is simple. A wire extends from each clock to the central clock, and at each clock is an electric call bell. A single cell in the battery is used, which gives enough electricity to call one bell, but not two. The possibility of the invention turns upon the fact that electricity will take the shortest path possible. When the bells are silent the electric current is passing along a direct line of wire, but when the bells sound the current is passing through several hundred feet of wire coiled at the bell, which closes the circuit when the fingers press the key in the central office. This change in the circuit is made by a simple arrangement in the clock, by which a lever is thrown in one position or another, turning the current into the coil or sending it straight on. If there were enough electricity on, the bells would all ring, but only enough is generated to ring one bell, and that bell is the one which, for the time being, is affected by the electricity in its coil. Since only one coil is affected at one time, only one bell will ring, and when a subscriber hears it he is sure it is for him. Mr. George H. Bliss is the patentee, and the patent is owned by the Signal Telephone Corporation.

A Queer Water Power.

In the neighborhood of Argostuli, in the Ionian Islands, a water power is utilized in a peculiar manner. At four points on the coast, the sea, at its ordinary level, enters a very narrow creek, or broken rocky channel, and after running somewhat rapidly through this channel and among broken fragments of rock, for a short distance, it gradually becomes sucked into the earth and disappears. By conducting the water through an artificial canal for a few yards, and so regulating its course and forcing all the water that enters to pass in a single stream beneath an undershot wheel, power enough is obtained in two cases to drive a mill. Mills have, in fact, been placed there by an enterprising Englishman, and are constantly at work. The stream, after being utilized, is allowed to take its natural channel, and is lost among the rocks.

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