THE COLUMBIA BICYCLE.

The bicycle furor which pervaded this country and Europe a few years ago has subsided into a solid interest in this means of locomotion, which is much more noticeable in England than in this country, although the bicycle is now very popular here, and is daily becoming more so. It has arrived at great perfection, and is constructed more scientifically than formerly It is of great practical utility as well as a rational means of amusement. It is, in fact, an ever-saddled horse that eats nothing and requires no care.

Undoubtedly the most perfect bicycle now made is the "Columbia," manufactured by the Pope Manufacturing Company, of 87 Summer street, Boston, Mass. This machine, which is shown in our engraving, has a steering head which is one solid forging. The backbones, which are made of steel, are large, light, strong, and rigid. The spring is attached by a joint to a small plate sliding on the backbone. The wheels are of the spider pattern, with steel V shaped fellies, with forged steel hubs, hardened in bearing parts. The back wheel and pedals run on coned bearings, one being adjustable, and are made so as to prevent the admission of dust and dirt. The front wheel bearings are conical and well hardened, and fitted with coned fastenings of India rubber, 1 inch on the front and ¾ inch diameter on the back wheel.

In the modern bicycle the seat is placed almost directly over the center of the front wheel, by which means a much larger wheel can be ridden, thus gaining in speed and making the act of propelling it more like walking, instead of pushing with the feet as in the velocipede, which is tiresome and injurious to the rider. Although our bicyclists have had very little experience compared with English riders, yet some long distances worth mentioning have been made. On November 27, 1877, Mr. A. D. Chandler rode from Leominster to Boston, a distance of 40 miles, in 4 hours. May, 1878, Russell Sharp and John Storer, from Boston to Newport, R. I., 72 miles, in 13 hours, including stoppages. Actual riding time, 10½ hours. August, 1878, H. E. Parkhurst rode from Clinton to Boston, 44 miles, in 5½ hours, without a stop, making the distance from South Framingham to Boston, 20½ miles, in 2 hours. Has also ridden from Boston to Natick and return, without a dismount, 36 miles in 3½ hours. October, 15, 1878, E. W. Pope and F. S. Jaquith rode in the suburbs of Boston, 77 miles in 11 hours, including stops. After having ridden 60 miles they made the distance from Wellesley to Newton, over 7 miles, in 38 minutes. October 19, 1878, G. R. Agassiz, on the Chestnut Hill road, traveled one mile in 3 minutes 21½ seconds, winning the Boston Bicycle Club Gold Medal. E. Costen and F. Smythe, September 2, 1876, on a turnpike road, made 205 miles in 22 hours.

We give a record of some professional and amateur bicycle runs made in England:

Quickest professional times—October 2, 1876, J. Keen, Molineaux Grounds, made 1 mile in 2 min. 56 1-5 secs. Same party, December 8, 1876, Lillie Bridge, made 10 miles in 33 minutes. Same rider, on same date and place, 20 miles in 1 hour 5 min. 34 sec. The same, October 9, 1876, Lillie Bridge, 50 miles in 3 hours 6 min. 45 sec. October 19, 1874, D. Stanton, Lillie Bridge, 106 miles in 7 hours 58 min. 54 sec. The same, March, 1878, Agricultural Hall, London, 1,000 miles in 6 days.

Quickest amateur times—T. T. East, Lillie Bridge, 1 mile in 2 min. 56 sec. September 11, 1875, W. Tylerson, Lillie Bridge, 10 miles in 34 min. 40¾ sec. May 15, 1876, Hon. I. K. Falconer, Cambridge University Grounds, 50 miles in 3 hours 20 min. 37 sec. June 10, 1878, F. E. Appleyard, turnpike road, Bath to London, 100 miles, in 7 hours 18 min. 55 sec. Stanley Thorpe, turnpike road from London to York, 105½ miles, in 22½ hours.

THE COLUMBIA BICYCLE.

EASILY MADE PHYSICAL APPARATUS.

BY GEO. M. HOPKINS.

But for the glass in the doors which imprison the physical apparatus in many of our institutions of learning, students would have little idea of the form or construction of the instruments, so many of which are now made for illustrating scientific principles, but which, alas! are doomed to eternal rest. Through fear of accident; through lack of confidence in their own ability to properly conduct experiments; or through indisposition to perform more than the absolutely necessary work, teachers too often ignore practical demonstration and permit students to rely on knowledge conveyed by text books, many of which are full of errors, while others lack that clearness, thoroughness, and conciseness which are necessary to a ready comprehension of the principles taught; in fact they are generally full of instruction on every point excepting the very one upon which instruction is most needed. There is scarcely a principle in physics that may not be easily demonstrated by experiment, and in the majority of cases the apparatus may be extemporized. To the young, one of the most interesting and instructive instruments is the air pump, as with it much that is daily seen and experienced may be explained.

The engraving shows in perspective in Fig. 1, and in section in Fig. 2, an air pump which may be readily made. The base, A, is a perfectly plain board, 8 inches wide, 15 inches long, and 1 inch thick. A 3-8 inch hole is bored longitudinally through the center, and near one end, two 1-16 inch holes are bored into the longitudinal hole at *a*, 3-4 inch apart. Another 1-16 inch hole is made at *b*, and another one at *c*. The board may be of any well seasoned wood that is not liable to warp. After boring it should receive several coats of good alcoholic shellac varnish on all sides and in the holes. When the last coat is applied a 6 inch disk, J, of elastic packing rubber, having a small central aperture, and which has previously received a coat of the same kind of varnish, is placed varnish side down upon the board with its central aperture coincident with the hole, *c*, in the board, and it is kept in position under slight pressure until the varnish dries, which will take a considerable time (a day or so), being confined between the two surfaces. To the base, A, two wooden standards, B, are secured, each 6 1-2 inches high and about 2 inches wide at the narrower end and 1-2 inch thick. They are two inches apart and are connected at the top by a cross piece, C. The base, A, standards, B, and cross piece, C, should be fastened together with long screws. The pump barrel, D, is a piece of glass tubing 1 1 2 inches internal diameter, and 6 inches long. A piece which is as nearly true and straight as possible should be selected. It may be cut from a long piece by turning it in a heated loop of heavy iron wire, which half encircles the tube. The tube should be turned back and forth at first until it begins to crack, when it should be turned slowly in one direction until it cracks entirely around. If the ends need to be squared up they may be readily ground upon an ordinary grindstone, or by moving it with a gyratory motion upon a slab of glass having on its surface some coarse emery and water. A piece of mandrel drawn brass tube will answer as a barrel equally as well as the glass tube.

The lower end of the pump barrel rests upon a soft rubber disk, E, and a ring of the same material is placed between the cross piece, C, and the upper end of the barrel. The rubber disk, E, has an oblong aperture, also a small circular one, as seen in Fig. 5. The oblong aperture is placed over the right hand hole at *a;* the small aperture over the left hand hole.

A disk, F, Fig. 4, of hard rubber, brass, or other suitable material, having its edge grooved, and having two small apertures (1-16 inch) which coincide with the holes at *a*, is covered on its under side with oiled silk, which is drawn over its edges and fastened by a stout thread wound in the groove. Two slits are cut in the oiled silk, one upon each side of the right hand hole, making a valve which works in the little chamber formed by the oblong hole in the packing disk, E; the oiled silk is removed around the left hand hole. The upper valve, which is shown in Fig. 3, consists of a strip of oiled silk, which covers the left hand hole and is fastened by a thread around the edges of the disk, as in the other case.

The disk, F, is placed upon the packing disk, E, and secured by four small screws that pass through both into the base.

The piston, H, consists of two disks of wood, which have been soaked in melted paraffin to prevent them from absorbing moisture. The lower one nearly fills the barrel; the upper one is small enough to receive between it and the barrel a leather packing, which is turned upward in the same manner as the packing of an ordinary cistern pump. The piston is fastened to the end of the wooden piston rod, I, by means of a long wood screw. The piston rod passes upward through a hole in the cross piece, C, and is provided with a suitable handle.

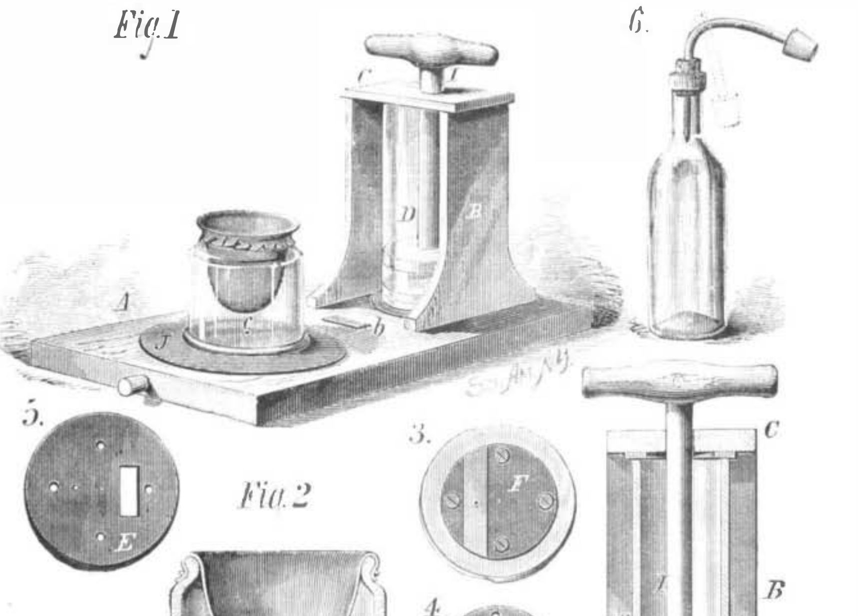
A rubber stopper is forced into the longitudinal hole in the bed to a point between the two holes at *a*, and another rubber stopper closes the opposite end of the hole. An oiled silk or flexible rubber flap or valve covers the hole, *b*. The piston should be greased with lard. By adding to the piston a second packing turned downward the pump may be used for the compression of air.

Any of the experiments performed with other air pumps may be repeated with this. A bottomless glass jar is shown in the present case upon the soft rubber disk, J. It has a thin piece of elastic rubber stretched over its mouth, and tied when the air is exhausted. External air pressure forces the elastic rubber downward. By substituting a piece of bladder for the rubber, it will burst with a loud report. By placing the hand over the mouth of the jar and exhausting the air, the fact that the air has weight will at once be realized.

A strong common fruit jar may be used as a receiver, and to insure a perfect joint with the rubber disk, a packing ring of very soft rubber may be interposed between the mouth of the jar and the rubber disk, J, and in any case the rubber disk and whatever is placed on it should be greased with lard to make a joint.

The fountain in vacuo requires no expensive apparatus. All that is needed is a small tube or jet, which may be either of metal or glass, a piece of stiff rubber tubing, and two good corks or rubber stoppers. One of the corks is inserted in the bottle and the jet is inserted in the cork, the rubber tube is slipped over the outer end of the jet tube and is fitted to a hole in the second cork, as seen in Fig. 6.

To exhaust the air from the bottle stop the hole, *c*, insert the cork that is on the end of the rubber tube in place of the stopper in the end of the bed. Work the pump, and when the air is exhausted bind the rubber tube, as indicated by the dotted lines, so as to close it; raise the valve from the hole, *b*, to admit air to the passage in the bed, and remove the cork on the rubber tube from the hole in the bed, and dip it in a vessel of water, at the same time allowing the rubber tube to straighten out.



A SIMPLE AIR PUMP.

To illustrate the principle of the Magdeburg hemispheres, make a ring of wood a little larger than a tumbler top, soak it in melted paraffin, attach to each side a packing ring of very soft rubber, fasten in one edge a piece of rubber tubing, which communicates with the interior of the ring; place on each side of the ring a tumbler with its mouth in contact with the packing ring; exhaust the air as in the case of the fountain bottle, and prevent its re-entrance by bending the tube short. The tumblers will press so firmly upon the ring that it will be difficult, if not impossible, to separate them from it.

It is not necessary to enumerate here the many interesting experiments that may be made with an air pump, as most of them are well known. If the construction of the pump has been made so simple as to enable the young readers of the SCIENTIFIC AMERICAN to construct one, the object of this article will have been attained.

THE LURAY CAVERN

BY H. C. HOVEY.

The marvels of this cave, lately opened in Page County, Va., have been made widely known through the columns of the New York *Herald*. Especial credit is due to Major A. J. Brand and J. J. Collins, C.E., for their graphic accounts, which have less of fancy and more of truth than commonly characterize the reports of enthusiastic explorers. We confess, however, that at first we were skeptical, and that our doubts have only been removed by an actual survey. And now, having gone through every avenue, hall, gulf, and gallery, and enjoying excellent opportunities for comparison with other caves elsewhere, we add our testimony that Luray Cavern may be safely counted among the chief wonders of the world.

The object now arrived at is to classify and explain phenomena, rather than to describe what is merely grotesque or beautiful, unless the ends of science may be thus promoted. Many of the things to be considered are so novel and ornate that any statements of their peculiarities, however coolly made, must seem florid and overdrawn to persons not familiar with cave scenery.

A cursory glance at the geology of the region will aid us in handling our subject. The official surveys are meager, and we had to rely chiefly upon such observations as could be made along the line of railroad from Harper's Ferry to New Market, where alternate beds of slate and limestone, displaced by volcanic upheavals, dip at an angle of 30° eastward into the Shenandoah valley. Crossing the lofty Massanutten range once by stage and the second time on foot, for the purpose of closer inspection, we saw impressive signs of the stupendous forces that have modified the original strata, lifting them vertically, and sometimes even inverting them. Amid all this rugged violence the general symmetry of periods is preserved; rising from Silurian limestones, through sub-carboniferous rocks, to thin deposits of coal said to lie on the highest peaks, and then descending through the same formations down the eastern slope.

This synclinal arrangement brings to view again in Page County the Lewisburg limestone (Formation II. of Rogers' Survey), which Fontaine locates between the Vespertine strata underneath and the Umbral series above. In this blue limestone, of the lower carboniferous period, many caves are found, the most noted of which, hitherto, has been the unique and attractive Weyer's Cave, about 1,600 yards long, and whose features were well described a few years ago, by Porte Crayon, in *Harper's Magazine*. It is in this same formation, indeed, as it appears with various modifications in different parts of the globe, that the most remarkable caverns in existence have been discovered; so that it is often spoken of by geological writers as the cavernous limestone. But in Virginia it has its peculiarities.

Volcanic action has been so powerful and recent, comparatively speaking, that masses of igneous rock are actually thrust through the sedimentary rocks, so that there is a dike of trap within a mile of Weyer's Cave. The veined condition of the limestone in Page County is due to such disturbances, by which it has been cleft into countless fissures, that were afterward filled by calcspar and silicates, with occasional streaks of the oxides of iron, manganese, and other metals and minerals, that play an important part in coloring the hard carbonates deposited on the walls of the underlying caverns. The loose rocks scattered on the surface are chiefly calcareous, often silicified, with occasional groups of quartz crystals and bowlders in the beds of streams.

The limestone in place is very compact and fine-grained, breaking with sharp edges. The color varies from light brown to deep blue, or even black, streaked, however, with fibers and veins of milk-white spar. Weathered surfaces are almost always stained with the oxide of iron. The analysis of five different specimens, from Luray and vicinity, showed an excess of carbonate of lime with from ten to forty per cent of the carbonate of magnesia, and even in one instance amounting to dolomite.

The valley of Luray is fertile, watered by the Hawksbill Creek, a tributary of the Shenandoah, and 150 miles from the sea coast. It is embosomed between the Massanutten range on the west and the Blue Ridge on the east. These ridges lie in vast folds and wrinkles, the fissures being often filled with metallic ores. Elevations found in the valley are, of course, such masses as had coherency enough to resist the wear of retreating waters by which gaps were opened in the mountain chains. Yet, as might be supposed, the lower hills are often pierced by the action of such mighty floods; and it is hardly necessary to refer any of the changes observed in these tunnels and hollows to the operation of volcanic forces. Water is as energetic as fire.

These geological conditions, thus hurriedly described, are favorable to rather deep and extensive excavations, marked by picturesque diversities and stalactitic ornamentation: but limited by the rapidly succeeding undulations of the surface and rifts dividing the strata.

There is no possibility of finding such immense domes, long avenues, and navigable rivers as characterize Mammoth Cave and others found in the vast, undisturbed, and homogeneous limestones of Kentucky and Indiana, varying in thickness from 50 to 500 feet, and oftentimes lying so nearly in their original position as to cause the surface above to assume the form of broad table lands, broken only by the sink-holes peculiar to all cave regions.

For more than fifty years an eminence a mile west of Luray has been known as Cave Hill. Climbing to its summit, which commands one of the finest views in the Old Dominion, we found a noble grove of pines and oaks, amid which is the pit-like entrance to Ruffner's Cave, full of drifted leaves and perilous of access. It has long been an object of local interest, but we explored it for only a short distance in order to ascertain its temperature, 60°, and its bearing, which is N. N. E.

Cave Hill is about 300 feet above the water level, toward which it slopes gradually, with many oval hollows called sink holes, each of which must have a subterranean outlet. Their axis invariably coincides with that of Ruffner's Cave, confirming the popular opinion that all the underlying cavities are in some way connected. One of these sink-holes on Mr. Brodus' land is fully 1,000 feet in diameter and 50 feet deep. Others at least two thirds as large are in adjacent fields.

At the foot of the long declivity, and at the distance of about a mile, is a pond near Blackford's furnace, fed by what is regarded as an unfathomable spring. A 50 pound weight attached to a cord 80 feet long failed to reach the bottom, and there is a legend of a wagon with four horses and the driver being swallowed down in this aqueous abyss without a vestige remaining. Doubtless it is really very deep, extending down to the level of Hawksbill Creek, and the volume of water it constantly pours forth is probably the drainage of all the cavities in the hill.

There is a small sink-hole about 70 feet lower than the summit and 320 paces N. E. from the mouth of the old cave. The crevice in the bottom of it was long since filled with stones and the space was overgrown with briers. Study of the topography led Messrs. Campbell and Stebbins to remove these obstructions, and dig through into what is now known to all the world as the Luray Cavern. That was done on the 13th of August, 1878. They only explored about 200 feet to a muddy pool, which they had there no means of crossing; and accordingly they returned to the surface, filled up the pit again, kept their secret, and bought 30 acres, including both the new orifice and Ruffner's Cave. Having thus gained possession by the double title of discovery and purchase, they proceeded with commendable enterprise to open their underground territory and make it accessible to the public.

Bridges have been thrown across pools and chasms that lie athwart the path; plank walks and tan bark have been laid down wherever needed on the main line; a large room at the further end has been floored; chandeliers are hung at several suitable points; railings guard the more dangerous places, and a building over the entrance is in process of erection for offices, dressingrooms, a cabinet, a dining hall, and other conveniences. Although but a portion of the cave is yet on exhibition, it has been visited by about 800 persons.

Mr. Stebbins was busied with these improvements, and we gladly accepted the services of Mr. A. J. Campbell as guide, whom we followed through every gallery and winding way, except three or four rooms now flooded by recent rains, and even into these we peered by the aid of fireworks, so as to get some idea of their dimensions and attractions.

Previous to our visit the cavern had never been illuminated by any better means than common lamps and candles in tin reflectors, or perhaps in a single instance by a few little tableaux-spirals. Anticipating this deficiency we had supplied ourselves beforehand with several pounds of the best quality of chemicals for making red and blue fires; and also with a large coil of magnesium ribbon, which we used very freely, as it burns with an intense white light, and emits no odor nor smoke, the sole product of combustion being wreaths of the pure oxide of the metal quickly falling to the ground.

The atmosphere within the cave is free from all hurtful gases, although Mr. Campbell has usually taken the precaution to lower a lighted candle into any pit he was to explore, in order to detect the presence of foul air. On the other hand we perceived no excess of oxygen, such as surcharges the atmosphere in caves where there is an abundance of saltpeter actively combining with lime and emitting free oxygen. The air is not exhilarating; it is merely wholesome and good to breathe everywhere, even in the deepest recesses. It sustains combustion well; but light seems to lack its usual power, owing to the fact that the atmosphere is optically as well as chemically pure. That is, there are no motes, or spores, or discernible atoms of any sort floating about, as in the sunbeams, each of which has its duty to perform in reflecting rays of light. In other words, cave chambers need a more powerful illumination to produce a given effect than would be required in a dark hall or church of the same size. This serves to explain the fact that the most honest observers nearly always have exaggerated estimates of cave distances. In one instance a room said to be 100 feet long, dwindled to 60 on measurement. Less extreme cases are common, and the cause of illusion having been pointed out, the necessity is evident of relying on the tape line rather than the eye; and where this is impracticable estimates should be cautiously made and from different positions.

The temperature observations made in all parts of the cave show an atmospheric range from 54° to 63°, averaging about 58°, which is 2° above that of Mammoth Cave, as fixed by repeated experiments made last summer. The temperature of the various bodies of water was about 54°. The mercury stood at 50° at the entrance. Hence there was a draught inward instead of outward, as would be the case in warm weather. The fact of fluctuations in the currents of air, in different parts of the cave, prove the existence of other openings than the one now known; and this ventilation aids us to understand the delightful purity of the cave atmosphere. It may be laid down as a rule in underground exploration, that wherever the draught changes, as indicated by wavering lights, an opening is near, either to the upper air or to some large arm of the cave.

A stairway of solid masonry leads down to the Vestibule, 30 feet below, where are stands and benches for the use of visitors. It is lighted by a chandelier hanging from the tip of a stalactite. It is a place of preparation. Putting on stout boots, overalls, and caps, and taking the tin reflector with its three candles provided for every visitor, we are ready to go on. The compass shows our path to lie due west. The eye, as soon as it has accommodated itself to the change of scene, is at once attracted by figures grotesque and majestic. Seldom does a cave have so fine an ante-chamber. On our right is the adit, now closed, through which the first explorers forced their passage. On the left is Specimen Avenue, from which the proprietors get most of the mementos tourists are allowed to take away. Next to it is Stebbins Avenue, which we leave, as we also do other side avenues, to be examined after we have followed out the main line.

Only ten paces in front of us is Washington's Pillar, broader at the base than at the top, a stalagmitic mass rising 25 feet from floor to roof, with a long diameter of 30 feet and a short one of 14. Its sides are fluted and jointed. The material is pure white carbonate of lime, fine grained, but not equal in quality to many to be found further within. A basin filled by trickling rills from the roof lies alongside the pillar. Against the opposite wall are rounded masses reminding one of the glyptodon and other monsters exhibited in museums.

Between a petrified cascade and a fossil garden we descend 18 steps to a lower floor, the roof retaining its altitude and supported by long slender shafts of alabaster. Brown buffaloes seem to hang from the roof, which on inspection were found to be spongoidal in appearance and blackened by the oxide of iron. They are really the network of silicious veins running through the limestone and remaining after the latter has been dissolved by acidulated water that would not affect silex. The floor was once lower than it now is, having been filled in by debris and washings from without. Fringed galleries mark the upper tier.

Next is the muddy lake already referred to as having put an end to the first exploring trip. On the second it was crossed in a small boat, and now it is bridged. It lies in a chasm from 12 to 30 feet wide and 75 in length. Midway there is a natural arch 4 feet wide and 8 high, through which the bridge is built.

The fish market is beyond this lake, getting its name from a row of folded stalactites, wet and shining, quite like a long string of black bass and catfish.

A hundred feet further on the way is obstructed, but with a small orifice through which a passage might be forced that would only lead to a point that is already accessible from another direction.

Our path now turns at right angles, up a flight of 25 steps, due north, to a floor on a level with the Vestibule. The roof is at this point nearly bare of ornaments. The floor is a bank of chalky substance, no doubt the product of disintegrated carbonates. The distance from floor to roof is only about 5 feet. But the width of these galleries is immense. We dispersed lights here and there in order to get some idea of their extent, and judged it to be 200 feet in one direction and 500 in another. The dimensions will more probably exceed than fall short of this estimate. Rambling to and fro we found many water-worn stalactites and columns half eaten through. This was plainly once a spacious hall, though now nearly obliterated by calcareous deposits and debris. It has been named the Elfin Ramble.

Trenches have been dug on the line of travel to enable persons to walk erect who prefer doing so to roving around as we delighted to do, spying out the secrets of the gnomes. Following one of these trenches we find ourselves on the edge of Pluto's Chasm, 500 feet long, 40 wide, and 70 deep, with a corresponding rift above, varying from 30 to 70 feet in height; making a total distance from top to bottom of from 100 to 140 feet.

Opposite where we stand is an alabaster formation surprisingly like a body of falling water suddenly congealed. There are many such objects in the cavern, and for want of some better term they are styled frozen or petrified cascades. On each side of this one are openings leading to a large room, to be reached perhaps at a future day by a bridge, but now by a circuitous route. The chasm is curved and its chord runs nearly S. W. to N. E. The compass was so affected by magnetic influences as not to be perfectly reliable; but