the latter can generate it, no matter how efficient the water-wheels and motors may be.

In Nevada County there is nearly 5,000 electric horse-power used for mine operation. The power house on the South Yuba supplies most of the mines with its electricity, but individual companies and groups of mines have organized in the last year to develop their own electric current. There are a number of streams in the mountains which have a head varying from 300 to 800, and the harnessing of these assures permanent cheap power for the mines. On the South Yuba there are two 600-horse-power plants working under 800 feet head, and the current is used almost entirely for mine purposes. The original machines in this region, consisting of two 330-kilowatt motors, are still in active operation, one working at 190 feet head, and the other at 800 feet.

In Grass Valley there is one mill that is driven entirely by electric synchronous motors. There are forty stamps and sixteen concentrators operated there, and the current is transmitted from the distant power house and sold by meter. It has been found that electricity operates a quartz mill cheaper than any other power.

There are some rather anomalous conditions to be found in Nevada County where electricity has displaced steam. All the mining machinery was formerly driven by steam, and the work of displacing steam was slow. In order to save the old machinery the engineers adopted many peculiar devices. But electricity has triumphed, and steam is practically abolished owing to the high cost of fuel. The direct-current motors are used for pumping in connection with compressed air, and also in a more limited way for driving drills. It is doubtful if compressed air for driving drills, pumps, and a few other machines will be displaced by the electric motor. In drilling with compressed air it has been found that the exhaust air proves of great value in ventilation. Electric drilling cannot offer such advantages unless worked in combination with a system of electric fans. While electricity is used for driving the compressors, working the mine house hoists and operating pumps, it has so far made little progress in drilling. Electrically-driven mine pumps have proved popular and profitable in this region, and two new ones are being installed, one at the 700-foot level and another at the 1,000-foot level. The success and profits of these new large pumps will naturally influence the construction of others, for mining companies are quick to note the practical advantages of any new departure.

In the matter of ventilation by exhaust fans, the mines are still inadequately supplied, but their introduction is being steadily pushed. Estimating current at ten cents per kilowatt-hour, the cost of exhausting 1,000,000 cubic feet of air by the slow-speed blower has been found to average 44.2 cents, and by the high-speed blower only 17.2 cents. The installation of the latter in preference to the former is therefore an assured fact, and a number of 20 horse-power motors are used for driving fans from six to nine feet in diameter.

HOW MUCH DOES THE UNIVERSE WEIGH?

BY PROF. EDGAR L. LARKIN.

The laws of attraction, motion, and centrifugal tendency are known in every detail, and with great accuracy. Three centuries of mathematical investigation revealed all their mysteries. The attractions and motions in this note are those in free space, between the distant stars. When one cosmical body is seen revolving around another, as sun about sun, or planets around suns, the combined mass of both may be easily determined, if the distance of the earth from the flying bodies is known. For the quantity of matter required to exert attraction sufficient to impart any velocity to any body at any distance is known to mathematicians. Thus, suppose the sidereal structure to have a boundary, and that its distance from the earth is known. Imagine a body entirely outside, to be in motion, falling toward its center of gravity, then if the speed and distance of the falling body could be discovered, the entire universe can be "weighed," that is, the quantity of matter it contains is capable of computation. Or, if the location of the center of gravity of the stellar hosts could be detected, and a sun should happen to be flying through it, then, again, the mass of all the stars could be found, if the speed of the moving sun and its distance from us were known.

All suns are in motion; it is impossible for one to remain at rest. If one is coming toward the earth on a straight line, or receding, the spectroscope—that marvel of all ages, and one of the most powerful engines in the hand of man for the conquest of the universe—tells its velocity of approach or recession. If a sun is flying through waste places in space, in a direction at right angles to a line drawn to it from the earth; its motion can at once be measured with a telescope and micrometer. And if the directions of stellar motions make angles with this line, the motion can be resolved into component parts by the usual formulas.

Careful research has long been made on the star No. 1830 in the catalogue of Groombridge. It moves with an angular velocity of seven seconds of arc per annum. There are 1,296,000 seconds in every circle, which divided by 7, equals 185,000, or the number of years required to traverse the circumference of the celestial vault. The distance of this star is not known with accuracy. Some catalogues omit its parallax, others say 0.1 sec. and another 0.13 sec. If exactly 0.1 sec., its distance from the earth would come out 2,062,650 times greater than that of the sun, or 192 trillion miles. So it will be taken at 200 trillion; for calling it 190 or 210 will not make an error in the result greater than an infinitesimal of the first order. And with a distance of 200 trillion miles, and a period of revolution of 185,000 years, the terrific orbital velocity of 200 miles per second appears. This is absolutely overwhelming even to the trained minds of those accustomed to revel in great numbers. The object now sought is to find the quantity of matter within a sphere having the diameter of this mighty orbit, 400 trillion miles. Perhaps the simplest way to get at this is to find the centrifugal tendency set up by this orbital speed. If the star moves on a circular orbit, this tendency equals the attraction of all the matter within. The same is true of an ellipse with the proper modifications for eccentricity. Tie a cord to a stone, and whirl it around the hand. The pull on the string is centrifugal tendency, and is equal to the square of the velocity of the stone, divided by the length of the string from the hand to the stone. And 200 squared equals 40,000, which divided by 200 trillion gives a quotient of one-five-billionth.

That is, the centrifugal tendency is equal to an acceleration of the one-five-billionth part of a mile per second. This is cleared by saying that if the star could come to an absolute rest, then it would instantly start to fall toward the center of gravity of all the matter inside of a sphere having a diameter equal to that of its orbit. And at the exact end of the first second of its fall, it would be falling with a velocity of one five-billionth of a mile per second. The fall would be due to gravity; but as it does not approach the center, but keeps on its orbit, the centrifugal tendency exactly balances the attraction. Thus in this roundabout way, the force of gravity exerted by the matter acting on the star is found. So far, no idea is had of the quantity of matter able to impart this velocity to a falling body 200 trillion miles from its center of mass. It is possible to approach the problem by comparing this force and distance with a body whose attraction and distance are known. Suppose our sun is selected for trial. Take a stone to within one mile or so of the sun and drop it. At the end of the first second, it will be falling with a velocity of seventeen hundredths of a mile per second. This is the well-known velocity potential of the sun, and is called, for short, "solar gravity." Now it must be found how fast the stone would be falling at the end of the first second, if taken to a distance of 200 trillion miles and let fall. Gravity varies inversely as the square of the distance. So the 0.17 of a mile divided by the square of the distance to 1830 Groombridge will give the desired quantity. But it would never do to divide the 0.17 by 200 trillion squared, but by the square of its ratio to the radius of the sun, which call 400,000 miles.

This is not obscure, for a stone falling on the sun's surface is 400,000 or more miles from the center. This is equal to one (1). To find the ratio, divide 200 trillion by 400,000. The quotient is five hundred million, whose square is 25 quintillion. Now everything is ready to find the mass of matter within the orbit of the star. For 0.17 divided by 25 quintillion, equals 0.000000000000000000068 of a mile per second velocity the mass of the sun could impart to a falling body at the end of the first second of its fall, at a distance of 200 trillion miles. But one five-billionth is enormously greater than this minute decimal. By actually dividing the greater by the less the appalling quotient of three hundred million is obtained, that is, there must be 300,000,000 times more matter acting on the star than is contained in our sun! And the sun contains 333,000 times more matter than is contained in our little world—our earth.

All these results are based upon the theory that the rapid star is moving around our sun in a regular orbit, and on the further hypothesis that no other matter exists. There is an untold quantity of matter in countless suns farther away, by far, than 1830 Groombridge. And it is not known whether the wandering sun is moving on a circular, or elliptical orbit, or on a straight line. But if on a straight line, the consequence is, that the 300,000,000 suns sink and wane away into the abyss of insignificance. See my article, "Velocity Potential of the Universe," SCIENTIFIC AMERICAN, February 18, 1905. It was there shown that if this star is moving on a straight line, and if it has been falling "forever," that is, having fallen from an "infinite" distance, and is now near the center of the sidereal universe, then the quantity of matter required to impart this colossal speed is thirty-two billion times that now contained in our modest sun. And how does a mere 300,000,000 compare with 32 billion? This computation is grounded on the hypothesis that the universe has a finite diameter of such length that light moving with the known velocity of 186,000 miles per second, requires 30,000 years to traverse it. But it matters little whether the edifice of stars is larger or smaller than this, the astounding fact is here—the star is moving with this frightful speed. And this motion has a mighty cause equal to the occasion. The quantity of matter capable of exerting this intensity of attraction is so far beyond the powers of mind, that there is no use beginning to think about it. Only one hundred million suns appear on the photographs of the entire celestial vault. Therefore, the *visible* universe is so utterly insignificant in comparison with the *invisible* that mathematicians are overwhelmed.

SCIENCE NOTES.

The International Aerostatic Commission has been holding its meetings at Paris, and these were closed during October. An important part of the work of the commission has been in forming a union among all the countries which are represented on the present occasion. This union will bear the name of International Federation of Aero Clubs and will have its headquarters along with the commission. At the recent meetings a series of international rules were adopted which had been drawn up by the Aero Club of France. But the regulations concerning the airships have been reserved for a future time. The next meeting of the International Commission will take place at Berlin in 1906.

The Governor-General of Egypt has promulgated an ordinance by which the government exercises its right of possession of any archæological remains and antiquities discovered in the Soudan, comprising buildings, monuments, remains, or objects of whatever age or people, which are illustrative of arts and sciences, industries, religion, history, letters, and customs, and that were built, made, or produced in the Soudan, or brought thereto prior to the year 1873 of the Gregorian calendar. Although the law is limited to the year 1873, the Governor-General is further empowered to declare right of possession to any object whatsoever in, or attached to, the soil after that year. This decree will deal the deathblow to the Egyptian "faker" and his nefarious traffic in coins, papyri, and other spurious antiquities, in the sale of which he plies a thriving trade during the winter season among the credulous tourists.

A very convenient process of obtaining a dilute solution of hydroxyl has been described by Dr. J. F. Jaubert, an eminent chemist of Paris, who is already known for his preparation of "oxylith," by which oxygen gas is formed from water. The present process originated by observing the action of boric acid upon peroxide of sodium. If we pour a powder formed of a proper mixture of boric acid and peroxide of sodium into water; the powder begins to dissolve, but after a certain time a crystalline deposit is formed which seems to correspond to the formula $B_4O_8Na_2 + 10H_2O$. This body gives hydroxyl by simply dissolving it in water, according to the reaction $B_4O_8Na_2 + H_2O = B_4O_7Na_2 + H_2O_2$. The solution keeps well without decomposing rapidly. After a month it still keeps 56 per cent of the original active oxygen. M. Jaubert calls the crystalline substance which is thus isolated by the name of *perborax*. When recrystallized for a number of times it forms crystals which contain an increasing quantity of active oxygen, and we find thus another compound, $BO_3Na + 4H_2O$, known as *perborate*. It keeps indefinitely when dry, and gives hydroxyl by simply dissolving it in water, but this solution is alkaline, and it must be prepared just when it is needed. The perborate has antiseptic properties, and can be used in surgery.

Some interesting researches in the treatment of rabies by the rays of radium have been made by two Italian savants, Tizzoni and Bongiovanni. In some cases they act upon the virus itself, and in others upon the animals. By exposing the virus to the radium rays it is rapidly transformed into a very active vaccine. The exposure varies from four to thirty-six hours. When a drop of the vaccine is injected into the animal's eye, he is found to be protected against the inoculation with a dog's virus such as readily killed the other animals. As to animals which were already under the influence of the virus, the seances of radiotherapy (one hour each) must be commenced at least ten hours after inoculation. But by a powerful sample of radium, and a series of exposures of several hours for six days, they find that they can save animals even forty-eight or one hundred hours after inoculation, while the animals used for a check on the method all died. Especially striking are the experiments with the rabbit, where it succumbs rapidly to the virus. Under the radium treatment we see the nervous phenomena retrocede and the fever diminish, with a gain in weight. The effects thus disappear in one case, while with a second animal, untreated, they go on increasing at the same time and soon end in death. This new application of radium will no doubt prove valuable.