Scientific American.

ESTABLISHED 1845.

MUNN & CO., Editors and Proprietors.

PUBLISHED WEEKLY AT

No. 361 BROADWAY, NEW YORK.

O. D. MUNN. A. E. BEACH.

TERMS FOR THE SCIENTIFIC AMERICAN.

One copy, one year, for the U. S., Canada or Mexico.................. $3 00
One copy, six months, for the U. S., Canada or Mexico................ 1 50
One copy, one year, to any foreign country belonging to Postal Union. 4 00

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MUNN & CO., 361 Broadway, corner of Franklin Street, New York.

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NEW YORK, SATURDAY, MARCH 19, 1892.

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ACETATE OF SODA WARMERS AND CAUSTIC SODA STEAM BOILERS.

In France acetate of soda has received an extensive application by railroad companies for the purpose of supplying foot warmers. The principle on which it operates and even its true functions are not generally understood.

Sodium acetate is used in the class of foot warmers and similar devices as a factor in the storage of heat. If a brick is warmed in an oven, it represents a source of heat which will supply a greater or less quantity in proportion to the degree of heat which has been imparted to it. A bottle of hot water is of the same category. The weight of the substance heated, its temperature, and its specific heat determine the quantity of heat which is absorbed and will be given out.

In sodium acetate a fourth element enters into the problem. It is a solid crystalline salt, having three molecules of water of crystallization. It possesses the property of dissolving at a boiling temperature in one part by weight of water. If allowed to cool, most of it crystallizes out, leaving about one-third still in solution in the mother liquor. If the apparently dry salt is heated, it liquefies in its water of crystallization, what is practically a fusion of the salt resulting. If kept in this state of fusion in an open vessel, the water gradually evaporates and the salt becomes anhydrous.

The melting of the crystals occurs at a comparatively low temperature. The fusion begins at 136° F., and at 167° F. is complete. As this fusion involves the conversion of a body from the solid into the liquid state, a large number of heat units are absorbed in the process; in other words, a large quantity of heat is rendered latent. This heat is given off during the solidification of the material.

The method for its use consists in packing cases of convenient size and shape for foot warmers and other purposes, as desired, with the salt. These cases should be closed. Placed for a short time in boiling water, the temperature of liquefaction is soon attained, and the salt remains practically at that temperature until melted. The action, though not so definite as regards the point of fusion, is identical with that of the water of melting ice, which cannot pass 32° F. as long as any solid ice remains. The case of melted acetate is now charged with latent as well as sensible heat. In use the salt gradually solidifies, but as it does this maintains its temperature of fusion approximately until it is solid. Then the loss of sensible heat begins and it rapidly cools.

The last described action is again comparable to that of water freezing. As long as liquid water remains in a vessel the temperature, except under special conditions, cannot fall below 32° F. In the case of sodium acetate, the temperature cannot go much below 136° F. until the whole mass is solidified.

When a brick or a metallic slab is used for a foot warmer, the low specific heat of the material renders it ineffective in proportion to its weight. Hot water, on the other hand, is effective, because of its high specific heat, but is too bulky. The sodium acetate seems to avoid both difficulties.

This use of the above salt must not be confounded with the application of caustic soda or sodium hydrate for the generation of steam. In the latter application a direct chemical act of combination is utilized. Water has a strong affinity for sodium hydrate, and unites with it with the production of heat. A parallel case is seen in the uniting of water with quicklime, the heat produced in which operation is familiar to all. The "caustic soda boiler" as it is termed has melted caustic soda surrounding its water chamber. This is necessarily hot when introduced, so that steam is at first generated by the sensible heat. The exhaust steam from the engine is blown into the caustic soda. This, by its combination with the sodium hydrate, generates additional heat. The process goes on until the caustic soda solution becomes so weakened by the water absorbed that it ceases to respond enough to be effective in maintaining the steam pressure in the boiler.

The caustic soda boiler has been successfully tried in the form of locomotives for tramways, tunnels, and in a submarine torpedo boat. It is evident that its advantage in not exhausting the oxygen of the air renders it peculiarly adapted for such purposes. Up to the present time it has been used very little.

Great Bodies of Fresh Water.

Geographers claim that there are twenty-five rivers on the globe which have a total length each of over 1,000 miles. Of these, two, the Mississippi from the source of the Missouri in the Rocky Mountains to the Eads jetties, and the Amazon from the source of the Beni to the isle of Marajo, are over 4,000 miles in length. To be exact, the former is 4,300 and the latter 4,029 miles from the source to the places where their waters are mingled with those of the ocean. Four claim a total length of over 3,000 and under 4,000. They are the Yenisei in Asia, length 3,580; the Kiang, Asia, length 3,900; the Nile, Africa, 3,240; and the Hoang-ho, Asia, which is 3,040 miles. Seven streams on the globe are under 3,000 and over 2,000 miles in length, the Volga in Russia and the Amoor in Asia each being 2,500 miles in length; two are 2,800 miles long, the Mackenzie in British America and the Platte in South America. The Rio Bravo in North America, the Rio Madeira in South America, and the Niger in Africa are each 2,300 miles from end to end. The Arkansas River just comes inside of this 2,000 mile limit. Ten of the great rivers of the world are over 1,000 and under 2,000 miles in length. Three of these are in North America, the Red River 1,520, Ohio 1,480, and the St. Lawrence 1,450. South America has also three in this list, the Rio Negro 1,650, Orinoco 1,600, and the Uruguay 1,100 miles. Asia has three in the same list, the Euphrates 1,900 miles, and the Tigris and Ganges, each of which is about 1,300 miles. In the group of great rivers, the St. Lawrence is the most remarkable. It constitutes by far the largest body of fresh water in the world. If we include the great lakes and tributary rivers, with the St Lawrence system, as they cover about 73,000 square miles, the aggregate represents not less than 9,000 solid miles of water. The unthinkable size of this mass may be better comprehended when we consider the figures of Professor Cyrus C. Dinwidde, who says that it would take over forty years for this entire mass to pour over Niagara at the computed rate of 1,000,000 cubic feet per second.

Indigo.

The chief source of natural indigo is the various species of *Indigofera*, especially *Indigofera tinctoria*, which are cultivated in India, China, and South America. It is also contained in European woad (*Isatis tinctoria*) and a few other plants, the cultivation of which for the production of indigo was a flourishing industry from the ninth to the sixteenth century, and further, one which, thanks to the decrees of the ruling powers in England, France, and Germany, was the cause of delaying the introduction of the "devouring devil's color," as the Indian indigo blue was formerly called. The cultivation of European woad is to-day almost an extinct industry, although up to the commencement of the seventeenth century it was a source of considerable revenue both in France and Germany. The color is not contained in the free state in these plants, but as what is called a glucoside, to which the name of *indican* has been given. In this glucoside the indigo is held in combination with a kind of sugar —glucose—which former undergoes decomposition under certain well defined conditions with the separation of indigo blue. It is the *Indigofera* plants of India, China, and South America, especially the first of these, from which the color is now prepared. The method of its preparation is very simple, although considerable attention is paid to the treatment of the soil previous to the planting of the seeds. Ten to fourteen days suffice for the first appearance of the shoots above the soil, after which they continue to grow rapidly. Shortly before flowering, or about three months after sowing, the plants are cut off close to the ground, and are then ready for extracting the color. After cropping the plants are again allowed to grow until they are sufficiently mature to admit of a second cutting. Occasionally a third and even a fourth crop is made, but each of these contains successively less and less of the indican. The cut plants are at once placed in large stone cisterns or fermenting vats, called "steepers," where they are covered with water, and kept in position by means of boards and heavy stones.

Overeating vs. Overwork.

An abuse that tends to the injury of brain workers is excessive eating. A writer in the *Medical Mirror* recalls to mind several active brain workers who suddenly broke down, and fancied that it was due to brain fatigue, when, as a matter of fact, it was due to overstuffing of their stomachs. The furnace connected with mental machinery became clogged up with ashes and carbon in various shapes and forms, and as a result disease came, and before the cases were fully appreciated, a demoralized condition of the nervous systems was manifested, and they laid the flattering unction to their souls that they had indulged in mental overwork. Hard work, mental or physical, rarely ever kills. If a mild amount of physical exercise be taken, and a judicious amount of food be furnished, the bowels kept open in the proper manner, the surface protected with proper clothing, and the individual cultivates a philosophical nature and absolutely resolves to permit nothing to annoy or fret him, the chances are that he can do an almost unlimited amount of work for an indefinite length of time, bearing in mind always that when weariness comes, he must rest, and not take stimulants and work upon false capital. The tired, worn-out slave should not be scourged to additional labor. Under such stimulus, the slave may do the task, but he soon becomes crippled and unfit for work. The secret of successful work lies in the direction of selecting good, nutritious, digestible food, taken in proper quantities, the adopting of regular methods of work, the rule of resting when pronounced fatigue presents itself, determining absolutely not to permit friction, worry, or fretting to enter into his life, and the cultivation of the Christian graces, charity, patience, and philosophy.

The Present Sun Spot.

Mr. Christie, the Astronomer Royal, informed the representative of the London *Globe* that this is the largest spot yet photographed at the Greenwich Observatory (where the sun has been regularly and systematically photographed since 1873), and that the greatest attention has been paid to it, with a view to clear up, as far as possible, moot points with regard to the cause, periodicity, and, perhaps, even more particularly, the magnetic disturbance which these spots bring about on this earth. Some excellent photographs have been secured, but, unfortunately, on several days the sun was obscured, and until photographs are received from India or Mauritius the investigation cannot be regarded as complete. However, the information which Mr. Christie has obtained is of the greatest interest and value. In the first place, the spot is found to be composed of two nuclei, very black, surrounded, as usual, by a penumbra, or fringe, and with several smaller nuclei connected with it. Occupying as it does an area of about $\frac{1}{350}$ of the face of the sun as we see it, the "spot"—still to speak of it in the singular number—is plainly shown on the negatives taken at the observatory; photographic plates ten inches square being used, and the solar disk being eight inches in diameter. Without, therefore, the aid of a magnifying glass the unusual size and importance of the spot are at once evident. But it is when the negative is placed under the microscope and accurately measured that the details of its size become more striking, for it is found that, while its greatest length is about 100,000 miles, and its greatest breadth 60,000 miles, the whole group extends over 150,000 miles.

Asked as to what was the cause of these spots, Mr. Christie said that there had been several theories framed to account for the phenomenon, but none that were entirely satisfactory. There were those, for instance, of Faye, Secchi, and Lockyer. The theory of the last named was that the spots are caused by a bombardment of meteoric matter falling into the sun, and causing a great "splash." The nucleus, as the dark part is called, is cold, and is at a lower level than the general surface of the sun; while around the spot are generally seen what are called *faculæ*, part of the sun's surface which are raised up. Often by means of the spectroscope can be traced moving masses of molten matter surging round and over the nucleus. The apparent movement of the spot across the face of the sun is, of course, the movement of the sun itself carrying the so-called spot with it. On these points Mr. Christie was careful to state that all is conjecture; and he pointed out, as an objection to Mr. Lockyer's theory, that while the spots never appear far from the sun's center, the nearer the spot is to the solar equator the faster it appears to move; a spot at the extreme limit from the equator taking two days longer to complete the circuit than one near to it. What he was able to speak more positively upon from the records at the observatory was the characteristics of the spots as they have been observed. In this connection a very valuable series of diagrams have been prepared by Mr. Ellis, both from the observations since 1873 and from the records prior to that year, showing not only that the magnetic disturbances have been coincident with the appearance of the spots, but that the intensity of the disturbance has been in exact ratio with the size of the spot. They further show that the "spottiness" of the sun reaches its maximum every eleven years, dying gradually down to its minimum of absolute freedom from spots, and as gradually increasing. There was, for instance, a minimum in 1878 and a maximum at the end of 1882 or the beginning of 1883. Then, again, there was a minimum in 1889, since which year the number and frequency of the spots has been increasing. It is a notable fact that when there are the fewest spots they come near the equator, but when a fresh cycle begins the spots appear in higher latitudes—about 35° or so from the equator, though never appearing at a greater distance than 40°.

These are the solar phenomena in connection with the spots. The terrestrial magnetic phenomena are equally striking, the magnetic storms or disturbances being of great extent—amounting to several degrees in the deviation of the compass. In the present instance, soon after the spot had passed the central meridian, there was a great magnetic disturbance from noon on Saturday to noon on Sunday, and that was accompanied by aurora on Saturday night. During this period both the movement of the needle to the north and its attraction to the earth showed a great disturbance. This has been fixed by the recording instruments at Greenwich, which work in this way. In the point of the magnetized needle is a small mirror, which reflects light upon sensitized paper. Ordinarily, therefore, there is on the paper, which revolves on a drum, a continuous line, which shows that the needle has been quiescent. But when the magnetic disturbance of Saturday set in, instead of a straight line there was recorded a series of zigzag lines, showing that the needle was darting from one side to the other to such an extent as to get off the paper—some four or five inches in width—on both sides, many times, and exactly the same results were found in the register of currents passing through the earth. The matter of interest now, said Mr. Christie, is to discuss what is the connection between the sun spots and these extraordinary magnetic disturbances. There are now three or four marked cases on record of large spots on the sun being coincident with these disturbances on the scale experienced during the past few days; but while there are no cases of a large spot being seen without magnetic disturbances being felt, there are cases in which the latter have been experienced without sun spots being visible. This might be urged as upsetting the theory; but we only see what is going on on one side of the sun, and it is very possible the spot was "on the other side;" so that the absence of a visible spot cannot be held to prove that there is nothing on the sun causing the disturbance.

The Screw Propeller.

BY SAMUEL NOTT, C.E.

In these days of high art in using steam power it is interesting to call to mind the day of small things, within the memory of thousands of people now living. I find a few notes on this subject in an unexpected quarter, namely, in Bishop Heber's travels in India, which he made tediously by sail on the sea, by oar, setting pole, and sail on the rivers, and, on land, by palanquin, horse, and elephant, through sections now long traversed by railroads. His notes are the more interesting, because he was a good man and a keen observer—"a godly gentleman and a great lover of learning," as was said of John Harvard, the founder of Harvard College, by one of his contemporaries. Nothing escaped the keen eye and attention of the bishop. He visited the King of Oude in 1824, and the king talked about steam vessels, speaking particularly of a new way of propelling ships by a spiral wheel at the bottom of the vessel, which an English engineer in his pay had invented; and in a letter dated at Calcutta on December 14, 1825, he says the steamboat long promised from England, the Enterprise, is at length arrived, after a passage of nearly four months. Here we have an account of one of the earliest experiments with the screw propeller, made by an East India king living away up in the interior; and of the first steamer by the Cape of Good Hope to India.

The late John Ericsson, whose remains were not long ago borne to his native Sweden by a United States ship of war, in consideration of his invaluable services in the late war, was the man of all others to persevere in making the screw propeller a power throughout the world. Previous to 1839 Ericsson tried unsuccessfully to introduce it in England, and came to the United States. In 1840 the English woke up, and the propeller came rapidly into use in England. In 1841 the Princeton was built by our own government, and was the first vessel with a screw propeller in this country. The introduction of the propeller was slow for ten or fifteen years, but now for more than fifteen years it has been the only mode of propulsion used on sea-going steam vessels and tug boats. There is no more animating and impressive sight in busy harbors and on busy rivers than to see the lively tug boats darting about, towing the largest ships with ease; and it is hard to realize that even in Boston harbor, for instance, there were no regular tug boats until, mainly through the continued efforts of John Ericsson, the screw propeller came into general use. Truly, "Peace hath her victories, as well as war."—*The Locomotive.*

A Wonderful Star that No Man Has Yet Seen.

The many wonderful discoveries in astronomy recently made by the aid of photography have seemed to leave the older methods of astronomical investigation far in the rear. But just now Mr. S. C. Chandler, of Boston, has made what may be called a discovery by the aid of mathematical methods, recalling the achievement of Leverrier and Adams in the detection of Neptune fifty years ago. There is in the northern sky a star known as Algol, which the sharp-sighted Arabs who discovered its variations in light called the demon star. Every two days twenty hours and forty-nine minutes this star suddenly begins to fade, and continues to grow fainter for three or four hours, at the end of which it has sunk from the second to nearly the fourth magnitude. After remaining thus for a few minutes it begins to brighten, and in the course of three or four hours more regains its former brilliancy. Within the past few years it has been discovered that there is a huge dark body revolving around Algol at a distance of some three million miles, and to this phenomenon the variations in Algol's light are due. At regular intervals this dark companion star comes into the line of sight between Algol and the earth, and thus partially eclipses Algol, cutting off, perhaps, five-sixths of its light.

These stars, Algol and its strange non-luminous comrade, are of great size, Algol itself being more than eleven hundred thousand miles in diameter, while the diameter of the dark body that circles around it is eight hundred and forty thousand miles.

Mr. Chandler, meditating on certain irregularities in the motions of Algol and its companion, suspected that they might be due to the presence of another invisible star in their immediate neighborhood. He carefully compared the observations back to the time of Goodricke, more than a hundred years ago, and pursuing a mathematical method similar to that which resulted in the discovery of Neptune through the effect of its attraction on Uranus, he arrived at the conclusion that such another star must actually exist. According to his conclusion this mysterious body is far more massive than either Algol or its companion, but does not give forth any perceptible light, and it forms a center of attraction around which both of the other stars revolve in a nearly circular orbit, in a period of one hundred and thirty years. Mr. Chandler's theory seems to fit in well with the observed irregularities of Algol. He remarks, moreover, that there are several other stars known to astronomers to be variable which evidently have one or more dark companions like those of Algol.

It is natural to inquire what is the nature of these mysterious dark bodies existing in the neighborhood of bright stars comparable in brilliancy with our own sun, and evidently obeying the same law of gravitation that prevails in our solar system. The primary distinction between a sun and a planet is that the former glows with a brilliant light of its own, while the planet, having been encrusted with a solid and opaque shell, only shines by the reflected light which it receives from its sun. The dark companions of Algol may then be regarded as in the planetary condition, at least so far as the question of luminosity is concerned. But they differ widely from any of the planets of our system in their great size as compared with the sun in whose neighborhood they circle. That companion of Algol, which by its eclipsing effect produces the variation in the light of the star, is not very far inferior in size to its bright comrade, while the greater dark body, whose existence seems to be demonstrated by Mr. Chandler's investigations, greatly exceeds them both in mass. Here, then, if we choose to adopt the idea that this great invisible orb around which Algol revolves is a planet in our sense of the word, we have a world which is the center of motion for the sun that illuminates it. This is going back to the old pre-Copernican idea of the earth as the center of the solar system, having the sun as its satellite. Such a system seems unnatural, if not impossible, because the ordinary laws of the radiation of heat require that a large body, other things being equal, should cool down from the solar to the planetary condition later than a smaller body. But it would seem that in the Algol system, for some reason yet to be discovered, the most massive member of the system has parted with its light and heat far earlier than one of the satellites revolving around it.

If it should prove to be true, as Mr. Chandler suggests, that there are other, and perhaps many other, systems similar to that of Algol, then we shall simply have additional evidence of the great variety that exists in the arrangements of the stellar universe. There really is no reason why we should take our own solar system as an invariable type to which all the other systems throughout space must correspond. It might be suggested that in the case of such a system as that of Algol, all the bodies belonging to it have long since become extinct through the operation of those laws of cosmical evolution which seem to be manifested in the universe at large as well as in our own planetary system, and that through some such cause as a collision one of the minor bodies of the system has again been brought to a luminous condition.

But there is no end of speculation when we try to interpret the wonderful discoveries with which the astronomy of our time is continually surprising the world.—*New York Sun.*

The Magnetic Properties of Oxygen.

Commenting on Prof. Dewar's recent experimental verification of the magnetic properties possessed by liquid oxygen, M. Guillaume points out, in *L'Industrie Electrique*, that if we accept the values found by Edmond Becquerel for the magnetic constant of oxygen, it ought, when in the liquid state, and in a field of medium strength, to possess a magnetic moment per cubic centimeter one-third of that of iron, and a magnetic moment per gramme twice as great as that of iron; so that the strange conclusion is forced upon us that oxygen is the most magnetic of substances. M. Guillaume also points out that liquid oxygen might be made to give a faithful and delicate representation of the distribution of the lines of force in a magnetic field, the liquid being heaped up in the strong places.

MESSRS. ESCHER, WYSS & CO., Zurich, Switzerland, received a first of prize £200, and Messrs. Ganz & Co., Buda-Pesth, Prof. A. Lupton, Leeds, and Mr. J. Sturgeon, Birmingham, England, received second prizes of £150 each, for projects for hydraulic development, prepared last summer, for the commission of the Niagara Falls Power Company. It will be remembered that none of the projects presented were approved and accepted in their entirety by the commission.