[International Review.]

THE CONSTITUTION OF THE SUN.

BY PROFESSOR C. A. YOUNG.

Number I.

THE CENTRAL CORE.

Probably no subjects of scientific research have ever attracted more attention than those relating to the sun. His preëminence in our system, as the controller of all planetary motions, and the origin and mainspring of all material energy in the earth and her sister worlds, invests with supreme interest every problem concerning his nature and modes of action.

As to the sun's central core, the opinion which now generally prevails, though not without some dissent, is that it is gaseous. The reasons which almost compel this conclusion are easily stated. In the first place, knowing the sun's distance, we readily compute its diameter, which turns out to be nearly 108 times that of the earth, or in round numbers 860,000 miles.* Now, since the bulks of different spheres are proportional to the cubes of their diameters, it follows that the volume of the sun, to use the technical term, is 108x 108x108 times greater than that of the earth; in other words, it would require about 1,250,000 of the earth to make a globe as large in volume as the sun.

According to the best determinations, we find that the sun is about 320,000 times as heavy as the earth; and since, as we have seen, it is a million and a quarter times as bulky, it follows that its average density is less than that of the earth nearly in the proportion of one to four; and this, although we know by means of the spectroscope that conspicuous among the materials of which the sun is composed are metals, whose density, even when not under pressure and in the liquid form, far exceeds that which has been mentioned. For since the earth has a mean specific gravity of about 5·5, it follows that that of the sun is only about 1·4, while the densities of iron, titanium, manganese, chromium, copper, zinc, magnesium, etc., range from 1·75 to 9. Of the substances known to exist in the sun, only sodium and hydrogen are lighter than the sun's mean density. It is to be remembered, also, that since the force of gravity at the sun's surface is twenty-eight times as great as on the earth, the effect of the weight of the strata near the surface, in compressing and increasing the density of the central parts must be correspondingly powerful. As things stand, then, there seems to be no possibility of admitting that the substances which compose the sun are mainly in the solid or liquid state, for in that case the mean density must almost necessarily far exceed that of the earth. This conclusion is strengthened by what we know of the intensity of the heat at the solar surface, where, although exposed to the cold of outer space, we find a temperature sufficient to keep the solar atmosphere charged with the vapors of the metals we have mentioned. We can hardly doubt, therefore, that in the interior of the sun the temperature must be such as to make the existence of the metals in the solid or even the liquid state quite impossible. And yet the theory that they are in a gaseous state is not without difficulties. A few years ago it would have been urged with great plausibility that, under such a pressure as must obtain at the center of the sun, every gas would necessarily be liquefied; and it would have been impossible to meet the objection by any knowledge then in our possession. The recent researches of Andrews have, however, shown that a vapor or gas, if above a certain critical temperature, refuses to be liquefied by any pressure whatever, but, growing denser and denser under the pressure, still maintains its gaseous characteristics, which are continuous expansibility under diminishing pressure without the formation of a free surface of equilibrium, continuous expansion under increasing temperature without the attainment of a boiling point, and, in the case of a mixture of different substances, a uniform diffusion of each through the whole space occupied, according to the law of Dalton and without regard to specific gravity.

These essential distinctions between liquids and condensed gases are often misunderstood; but it is the more necessary to keep sight of them, as in many most important respects the mechanical properties of gaseous matter, condensed by pressure to the specific gravity of water, are identical with those of liquids; especially if at the same time intensely heated—for then, as Maxwell has shown, the viscosity, or power of resisting motions, is greatly increased; so that a mass of hydrogen at the sun's center may very possibly in its mechanical behavior much more resemble pitch than what we are familiar with as gas and vapor.

It must be noted further, and is urged as an objection by many, though we fail to appreciate its force, that if the sun's central core is gaseous, then the temperature at the sun's center must be enormous—to be reckoned in millions of degrees, perhaps millions of millions. If it were not so, even the lightest gas, as hydrogen, at the temperature of the sun's surface, would, by the inconceivable (but not incalculable) pressure, be condensed so as to be hundreds of times heavier than platinum itself. We speak somewhat vaguely, because the numerical conditions of the problem are not very accurately known, though the general correctness of the result is certain. Heat, of enormous intensity, can alone counteract this effect, and give us the small density observed. For our own part, considering what we know of the amount, constancy, and permanence of the sun's radiation, we find no difficulty in conceding any internal temperature which may be necessary to account for the facts.

* Very few, we imagine, get from this bare statement any adequate conception of the vastness of the solar orb. Conceive the earth placed at its center so that the inner surface of the photospheric shell should be our sky; then the moon, which is distant nearly 240,000 miles, would pursue her accustomed orbit far within the bounding sphere; and indeed, if the earth had a second satellite at almost twice the moon's distance, this also would come within our firmament.

[The Telegraphic Journal.]

ELECTRO-DEPOSITION OF METALS.

BY J. T. SPRAGUE.

Number I.—PREPARATION OF THE ARTICLES.

The depositing of metals in the various forms required in the arts depends upon the practical application of the theoretical principles which have been frequently explained. The processes divide themselves into two general groups: 1. Electrotyping, the forming of a mass of metal intended to have a distinct existence of its own, and requiring therefore to possess a certain amount of strength or coherence. 2. Electroplating, in which a mere film of metal is to be employed as a covering to another metal, to beautify it or to protect it from atmospheric influences.

The essential distinction between the two processes is that in electroplating the two metals are desired to be brought into absolute molecular contact, so that they shall form one body, mechanically considered; this depends entirely upon the absence of any intervening substance, that is to say, upon the absolute cleanness of the surface to be coated. Under ordinary circumstances, every surface is coated with a very strongly adhering film of air, which appears to condense among the superficial molecules, and cling, as we see liquids do, to those surfaces which they can wet. This coating of air will prevent adherence unless it is very carefully removed; most metallic surfaces form either oxides or sulphides, and of course all collect a greasy film from the air, and the first and most essential operation is the removal of all these impurities, so as to present a pure metallic surface to the new metal to be incorporated with it.

In electrotyping, on the other hand, it is necessary to ensure the presence of an intervening film, which, while not resisting ordinary contact, will prevent true chemical or molecular contact. To effect this, after the surface to be deposited on (if metallic) is properly cleaned from everything which would deface the deposit, it should be lightly rubbed over with a leather or cloth moistened with turpentine in which a little beeswax has been dissolved—a piece the size of a pea to a quarter of a pint of turpentine will suffice—to prevent adhesion without filling up fine lines, etc.

The process of cleaning varies according to the nature of the objects and the solutions they are to be used with; these processes are mechanical and chemical. In mechanical cleaning, it is desirable, if the objects will permit, to expose them first to a red heat, and then to rub and polish them thoroughly by means of suitable brushes and polishing substances. The best apparatus for the purpose consists of circular brushes mounted on a spindle, driven by machinery or by a lathe. Circular pieces of wood, faced with leather, are also useful, as also the blocks of solid emery now so much used for grinding and polishing metals. A substitute for the latter may be usefully made by soaking a leather facing with glue, and coating well with emery, turning the wheel when nearly set against a roller, so as to consolidate the surface.

Most articles, however, are more rapidly and conveniently cleaned by chemical means. The first of these is the removal of grease by boiling in a solution of caustic soda, made by boiling 2 lbs. of common washing soda and ½ lb. quicklime in a gallon of water; after this they should be well brushed under water. The further processes will depend upon the nature of the objects.

1. Silver is washed in dilute nitric acid, then dipped for a moment in strong nitric acid, and well washed. Care must be taken that the water does not contain chlorine salts; if the ordinary supply does so, the first rinsing after acids must be made in water prepared for the purpose by removing the chlorine by adding to it a few drops of nitrate of silver, and allowing the chloride to settle.

2. Copper, brass and German silver are washed in a pickle of water 100 parts, oil of vitriol 100 parts, nitric acid (sp. gr. 1·3) 50 parts, hydrochloric acid 2 parts. Spots of verdigris should be first removed by rubbing with a piece of wood dipped in hydrochloric acid; they are then rinsed in water.

3. Britannia metal, pewter, tin, and lead cannot be well cleaned in acids, but are to be well rubbed in a fresh solution of caustic soda, and passed at once, without washing, into the depositing solution, which must be alkaline.

4. Iron and steel are soaked in water containing 1 lb. oil of vitriol to the gallon, with a little nitric and hydrochloric acids added. Cast iron requires a stronger solution, and careful rubbing with sand, &c., to remove scale and the carbon left by the acids. It is an advantage at times to connect them to a piece of zinc while cleaning. These metals should be cleaned just before placing in the depositing cell; and if they are placed in an alkaline solution, they should be rinsed and dipped in a solution of caustic soda, to remove all trace of acids.

5. Zinc may be cleaned like iron, with a dip into stronger acids before the final washing.

6. Solder requires special care, as the acids used with the objects produce upon it an insoluble coating, and an obstinate resistance to deposit is set up at the edge of the solder. The same remark applies to soft metal edgings and mounts. These should be rubbed with a strong caustic soda solution, rinsed, and then treated as follows:—Make a weak solution of nitrate of copper by dissolving copper in dilute nitric acid; to a camel hair or other soft brush, tie three or four fine iron wires to form part of the brush; dip this in the nitrate of copper, and draw over the solder, taking care that some of the iron wires touch it; a thin adherent of copper will form, and upon this a good deposit will take place.

7. Old work for replating must have the silver and gold carefully removed; if this is not done, there is apt to be a failure of contact at the edges of the old coatings, which causes blisters and stripping under the burnisher. The best mode of stripping is with the scratch brush, etc., as described for mechanical cleaning, but chemical means may be used. Gold is dissolved by strong nitric acid, to which common salt is gradually added; it may be collected afterwards by drying and fusing with soda or potash. Silver is similarly dissolved by strong sulphuric acid and crystals of saltpeter, and recovered by diluting and precipitating with hydrochloric acid, then reducing the chloride either by fusion with carbonate of soda, or by acid and zinc cuttings. Copper can be removed from silver by boiling with dilute hydrochloric acid, and tin and lead by a hot solution of perchloride of iron.

In preparing articles for silvering and gilding, a process of amalgamation is very commonly employed, by which a very thin film of mercury is formed over the surface, which makes a perfect connection between the two metals; this is effected by a solution of one ounce of mercury in dilute nitric acid, and then diluted to one gallon; there must always be a little free nitric acid present; articles dipped in this solution take a grayish color, which on brushing under water becomes a brilliant mercury surface. They must be at once transferred to the solution for coating, without exposure to the air. In the case of iron or steel articles, a similar process may be used, but in this case it is best to add to the solution an ounce of silver also dissolved in nitric acid. It requires great care to obtain a perfect mercury surface upon iron; occasionally sodium amalgam is rubbed over iron for this purpose; the iron must be very perfectly cleaned first.

Street Cars Propelled by Springs.

The winding-up of the spring barrels, which are carried under the car, is effected by engine power, located at suitable intervals along the track, as may be convenient for the run. The stationary engine drives by belt the horizontal shaft, carried in bearings, enclosed in a metallic tube or casing, beneath the roadway, and extending across the track; close alongside whereof a covered box is sunk in the roadway, enclosing a wheel, so shaped as to connect with the winding axle of the tramway car, and thus give the requisite motion thereto. On the arrival of a car at any station, the spring barrels are quickly wound up by the engine.

It has been computed that the actual tractive force, requisite to overcome the resistance of a street car weighing gross 5 tuns, is 60 lbs. on the driving wheels, corresponding to 720 lbs. on the periphery of the spring barrel; 24 lbs. and 288 lbs. respectively correspond to a gross weight of 2 tuns; and in like proportions for intermediate weights. So far as previous experience goes, a spring 6 lbs. in weight, exerting a direct pressure of 105 lbs., may be taken to represent the maximum in size and power of such steel springs. Under the stimulus applied by M. Leveaux's researches, the steel manufacturers of Sheffield, by special and improved plant, annealing ovens, and appliances, have turned out springs 50 to 60 feet long, capable when duly coiled of exerting a pressure of 800 lbs. to 900 lbs., without permanent set. In France, also, steel driving bands, with great elasticity, are made, 100 yards in length, so that the question of the possibility of obtaining springs of the requisite size and power is practically solved

M. Leveaux has had all the necessary mechanism and appliances made by a well known firm of engineers, so as to fit up a tramway car or cars for actual trial upon some of the lines of metropolitan tramways in London; for which indeed, the arrangements are now nearly complete, so that the practical working of the system will speedily receive a thorough public demonstration. We have ourselves had opportunities of seeing the potentialities of the principle, both in the model and full working size; and even in view of the sweeping change in the tramway system which is involved in its complete success and adoption, we cannot withhold the conviction that all the important practical difficulties have been effectually surmounted, reducing its practical realization to mere matters of detail. The working of the springs is entirely free from noise, perfectly smooth, easy, and effective, and completely under control, for application, cessation, and reversal.—*Iron.*

Wood Cutting by Electricity.

Professor Barnard, of Columbia College, writing to the New York *Times*, as an item of recent scientific news, says that the Abbé Moigno, in a recent number of his periodical, entitled *Les Mondes*, describes an invention which, he says, has recently been patented by Mr. George Robinson, of New York, for sawing wood by an entirely new, and what seems a sufficiently odd, process. The process consists in substituting instead of the saw a platinum wire, heated white hot by means of an electric current, etc.

The original account of this invention was published in the SCIENTIFIC AMERICAN, June 22, 1872. It was patented here in May of the same year.