color and brilliancy of the Wessell-alloyed silver remained unaffected. The same peculiarity has been observed by the writer personally in Mr. Wessell's low-priced nickeline metal, which holds a pure and strong lustre throughout indefinite exposure to every test that befalls (and befouls) a silver spoon in domestic use.

"INTEGRAL LUBRICATION."

Integral lubrication is an expression that has been selected to describe the effect of a lubricating element which is itself an *integral part* of the surfaces in contact and relative motion, as distinguished from a foreign or extraneous lubricant introduced between the surfaces, requiring constant renewal, and subject to displacement, consumption, waste, deterioration by heating, &c., and to various other imperfections and inconveniences.

Friction results from the resistance of particles in contact to change of position. Lubrication consists in their non-resistance to change of position, as in fluids. Within themselves, therefore, fluids have the property of integral lubrication. Interposed between solid surfaces, whose fixed particles resist change of position, fluids serve to separate such surfaces by a stratum of non-resistant or mobile particles, and thus supply *extraneous* lubrication.

The idea of establishing the lubricating, non-resistant or mobile element integrally in the bearings themselves, rather than extraneously as a distinct intermediate stratum, was the conception of Dr. Stuart Gwynn, the noted engineer and inventor, of two generations, to whom we owe the Gwynn pump and numerous other long established appliances. This idea is the basis of more than twenty patents, relating to the series of compositions by which it is realized under different conditions, all known under the common designation of METALINE.

The conception of union between the opposite properties of solidity and non-resistance, and of integrity and distinctness, in one metallic body, certainly had the boldness, as its realization showed the power, of a stroke of genius.

The important point to be reached by Dr. Gwynn, after his discovery of the possibility of "Integral Lubrication," to render it of practical value, was to make exact determinations of the effect produced on metals, their alloys, oxides, etc. by enormous pressure when they are put into hardened steel moulds of great strength. These trials extended over several years of time and under pressures from five tons or 666⅔ atmospheres to one hundred tons or 13,333⅓ atmospheres per square inch. In these trials he found, without doubt, the true law of the "*Flow of Solids.*" His determinations were finished in 1860.

This department of physics has, since then, been extensively worked by other scientists, and many of the results arrived at have been published. One of the latest of these contributions is an interesting memoir published in 1881 in the "*Revue Scientifique*," by Mr. W. Spring, a German chemist, from which we abstract as follows:

The substances experimented with were taken in the form of fine powder, and subjected, in a steel mould, to pressures varying from 2000 to 7000 atmospheres per square centimeter. Lead filings under a pressure of 2000 atmospheres were transformed into a solid block which no longer showed the least grain under the microscope, and the density of which was 11.5, while that of ordinary lead is 11.3 only. Under 5000 atmospheres the lead became fluid and ran out through the interstices of the apparatus. Toward 6000 atmospheres, zinc and tin appeared to liquefy. Powders of zinc and bismuth at 5000 to 6000 became solid blocks of a *crystalline* fracture. Powders of soft and of prismatic sulphur were transformed into solid blocks of octahedric sulphur. Red phosphorus appeared to pass into the denser state of black phosphorus. Binoxide of manganese and the sulphides of zinc and lead in powder, *weld* when compressed, and exhibit the appearance, respectively, of natural crystallized pyrosulite, blende, and galena. A number of pulverized salts solidify through pressure and become transparent, thus proving the union of the molecules.

The common property in Metaline and the natural lubricants (fluids) is, of course, mobility or non-resistance to change of position in the particles. This property or effect, results, again, from exceeding minuteness, hardness, roundness and polish of particles; obtained in the artificial instance, by pulverization, attrition, and extreme sifting of metallic particles. It is obvious that the particles of soft or brittle substances, such as flour of wheat or dust of stone, are not capable of the rounding polish and consequent slipperiness (integral lubrication) of metallic particles; nor yet of a kindly interpenetration with the surface particles of solid metal. Hardness, also, or resistance to change of form, coupled with non-resistance to change of position, may be an essential requisite to fluidity; so that possibly the particles of water or oil may be much harder as well as finer than those even of metals. The metals, however, are generally susceptible of a degree of polished and rounded comminution that yields a very slippery product. The fluid-like mobility of small shot is a rough illustration of this condition.

The next stage of the invention is to penetrate and incorporate the solid bearing surfaces with the non-resistant or mobile particles. This is effected by two operations, one the product and complement of the other. The prepared particles are in effect compressed into frequent sockets in the bearing surface, so as in the first place to occupy directly the larger part of its area, and in the second place to allow the outer particles (slightly raised) to attach to the microscopic inequalities of the revolving journal, and so migrate, filling both surfaces with a fine permanent ingredient of particles non-resistant to change of position. The particles are forced in with great power, by running a heavy journal at moderate speed, or a light one at a swift rate, with the cap screwed tight enough to stop the machinery or twist off the journal if oil instead of metaline were the lubricant. Under such incalculable concentration of force, the particles, instead of being worked out from between the surfaces, are held and incorporated, forming new surfaces of a permanent but peculiar character. Thenceforward, the interaction of these surfaces works infinitesimal movement, or mutual yielding to each other in their numberless infinitesimal particles, which nevertheless retain permanent cohesion by the same law that unites the more fixed particles of the solid metal; a state of movement in stability, foreign to our sensible impression from solids, yet quite as conceivable as the universal molecular motion supposed to constitute heat. A mechanical union of metallic substances seems to be realized, as different in effect as in method—and yet perhaps not so different in principle—from the results of cofusion or amalgamation.

There is nothing in experience to indicate abrasion between these surfaces, except from the gradual breaking off of the high points which the microscope reveals on the surface of the most highly polished journal, projecting above the metaline surface. In the course of years of running on heavy bearings, these points (which so rapidly blacken oil where it is used as the lubricant), become dislodged in such quantity as to cover the surfaces with rigid specks looking like emery under the glass. To prevent this, it is found advisable, once in two or three years, according to circumstances, to replug the bushing or box with metaline (again projecting a hair's breadth) so as replace that which is removed. By this means the bearings improve with use and progressively acquire a higher and higher finish, such, as tested by the microscope, that it is impossible to approximate it by any other method of finishing. Running in oil, on the contrary, wears out journals and misshapes boxes. The longest periods for which journals have as yet been run in metaline—say ten years—have developed no heating or wear, if the bushings have been properly cleaned and replugged once in two or three years. A "shakeless fit" can be secured with metaline, which, as before remarked, would render movement impossible with any mere interposed lubricant. Journals in metalined bearings, under the heaviest weight, or at the highest rate of speed (as in spindles and polishing lathes)

and even hot, as in the case of calendering and laundering rolls, or coffee-roasters, run perfectly dry, the year round, without attention, without heating unduly, or being injured by external heat, without perceptible wear or loosening, and with a usual reduction of power required, as compared with companion bearings running with oil under the same conditions. Thus the cost of oil is entirely saved while the cost of power is materially diminished; the usual wear of journals and bearings is practically eliminated, while the fit is so close as to exclude dust and preserve or rather improve their round and polish; the labor of cleaning and oiling, and interruptions and bills for repairing are saved; the greasing of fabrics, goods, buildings and machinery is abolished; and the serious danger of fire from oil and the spontaneous combustion of oily waste is wholly removed.

The authority for these comprehensive statements stands in the form of numerous certificates from prominent manufacturing firms, a few of which it will be only proper to cite in this connection, using their own words. Thus: Messrs. Bagnall & Loud, the Boston manufacturers of pulley-blocks, certify that their planing machine was fitted with metaline bearings four and a half years ago, and is still running on the same at the rate of 5000 revolutions per minute, averaging six or seven hours a day. No oil has been applied, and the shaft shows as handsome a polish as could be desired.—Day, Farrington & Co., hardware manufacturers, Brooklyn, report that their emery grinder, with heavy journals running 1600 revolutions per minute, after three and a quarter years without oil or attention, required new bushings from neglect to replug with metaline, which would have kept them up indefinitely. "The journals are a shakeless fit, and run cooler than another grinder running in oil."—In the machine shops of the New York & Harlem Railroad, a circular saw and a Daniels planer had been running on metaline bearings, 1800 and 2000 revolutions a minute, respectively, for three and four years: no lubricants being used, no care or attention being given them, and no wear perceptible.—The Inman line of Atlantic steamships, have used metaline in their wharf machinery for ten years. Their wharfinger and engineer certify to having used metaline gibs on a forty-horse wharf-engine for five and a half years, without lubrication or perceptible wear: where both gibs and slides running in oil used to cut out and require replacement every few weeks or months.—The Excelsior Brick & Stone Company, Philadelphia, state that the metaline bushings of their loose pulleys—48 inches diameter, 12-inch face, 2⅞-inch bore, friction-clutch, and runing 225 revolutions a minute—are as good after four years as when first put in, and fit the shaft as well, having had no lubrication or attention whatever.—The Washington Steam Laundry, New York, state that they introduced metaline bearings for the heated rolls of their ironing-machines about four years ago; resulting in complete relief from the constant difficulty, disadvantage and expense caused by such machinery running with oil.—A number of the most prominent manufacturing jewellers in New York, give certificates to the same effect with that of Baldwin, Sexton & Peterson, who say that they have used metaline bearings for five years without lubrication, at very high speed on polishing-lathes e'c., the journals running cold and with less power than others running with oil.—The Windsor Hotel, New York, after using metalined gibs for passenger elevators for several years, certifies that they are in good order and save the difficulty of keeping the well-way clean and free from the smell of oil.—One of the most extreme pressures that could be tried was that to which the leading blocks were subjected in hoisting granite and iron for the New York & Brooklyn Bridge, frequently causing a strain of four tons on a sheave. Before introducing metaline, the bushing and hardened steel rollers of a patent sheave would be cut completely out (says Engineer Collingwood) in four or five days. "Since metaline was put in, (over 18 months) we have had no occasion even to take out the pin, nor can we discover any appreciable wear."

We learn from *Iron* (London) the contents of a paper read by A. H. Bateman, Esq., F. C. S., before the British Association of Foremen Engineers and Draughtsmen. Mr. Bateman stated that, in London, there had been running, on metaline bearings, for the best part of a year, various kinds of main and counter shafting from 1½ to 3½ inches diameter, and from 150 to 450 revolutions per minute, loose pulleys as high as 700, and latheheads, 2000 revolutions. Elsewhere in England, there were five-inch shaftings and calendering rolls, under more than ten tons pressure; also, spinning frames, circular saws, planing machines, sewing machines, printing machines, cranks, bicycles, etc., running on the same material, without the use of oil. Works have been established on an ample scale in Dundee, Scotland, for metalining all kinds of machinery.

On the practical importance of this invention it seems unnecessary to enlarge, as every practical mind realizes at once that its value must be as diversified as the uses of machinery, and its desirable applications would form a catalogue too long for reading. A few of the lines of vast extent, in which beginnings or preparations have been made for applying metaline, may be noted with interest. The value of metaline to the millions of sewing machines in use suggests itself forcibly enough, from the repulsiveness of oil to the ladies who use them in contact with their carpets and clothing, and in making up rich and costly or delicate fabrics, which a spot of oil from the machine often ruins. The time taken up in oiling the machine is a burdensome tax on the operator, and the destruction of thousands of machines, through forgetfulness to oil them, is a still larger loss. Moreover, the nearly frictionless running of a metalined sewing machine yields the operator a sense of almost spontaneous motion in the instrument, and a delightful relief to the usual fatigue of propelling it; a strain which has, in fact, resulted in sad consequences to many female constitutions. No less obvious, too, is the value of integral lubrication, from its absolute cleanliness, in all machines for making and dressing fine fabrics of any kind.

Railroad journals running with oil cause daily detentions on every road, and frequent disasters by heating their boxes until the Babbitt or other metal is melted out and the train can be moved no further without great caution, delay and danger. A tragical train wreck resulted in Iowa, but a few days since, from the bursting of a wheel by a hot journal, in consequence of the exhaustion of the oil. Great numbers of men are constantly employed in examining, cleaning and oiling, and the expenditure for oil alone is an enormous amount, as well as that for replacing worn-out bushings and axles. When once a car or locomotive is properly fitted up with metaline bearings, these are all in order for one year at least, without a penny-worth further of material or labor, and without a possibility of danger or detention from hot boxes, want of lubrication, or wearing-out of journals and bushings.

Under the several patents for special applications, such as these and others, the American Metaline Company gives exclusive privilege to proper parties wishing to develop a particular use of metaline as a specialty. Metalined sewing machines are already the property of a New York company under the presidency of Madame Demorest, of fashion and pattern fame. Railway cars and engines are to be metalined by a close corporation of capitalists headed by Wm. Jennings Demorest, Esq., with a capital of $3,000,000. The application to sheaves, pulleyblocks, &c., has been taken up very successfully by Bagnall & Loud, Boston. Samuel S. Webber & Co., Manchester, N. H., have the manufacture of metalined spinning frames, &c., which has been tested thoroughly for years, and is now going into mills with many thousands of spindles. Metaline packings for steam, water and gas joints, pumps, &c., &c., are a specialty of Frank

Baldwin, 33 South street, New York. The Hopkins and Dickinson M'f'g Co,, 76 Reade St., N. Y., and Darlington, N. J., have the exclusive specialty of metalined sliding door sheaves and builders' hardware generally. But these illustrations need not be extended.

THE SUN.

By PROFESSOR C. A. YOUNG.

To the Editor of "SCIENCE."

DEAR SIR,—May I avail myself of the columns of your journal to correct a few serious errors which have come to light in my recent book on the Sun.

P. 16, near bottom.—The interval from the vernal equinox to the autumnal is 186 days, instead of 184, as stated. Of course the remaining part of the year is 179 days, not 181.

P. 44.—The earth would fall to the sun in about two months, not four.

P. 240, 241, and 279.—The candle power of the sun is given just four times too great. The figures printed express the number of candles which, distributed over the surface of an opaque globe, would give the same amount of light the sun does, each flame being considered as a small FLAT radiating surface. But this does not express the true ratio between the sun's light and that of a candle radiating freely in all directions.

P. 271.—In the formula for the number of calories of heat generated by the stoppage of a moving body, the denominator ought to be 8338 instead of 850. The factor g (9.81^m), having been accidentally omitted. In consequence, a few lines below, another 850 becomes 8338 also, and 300 ° becomes about 30°

There are a number of other minor errors, which it is hardly worth while to notice here, though they will be corrected in the second edition. C. A. YOUNG.

To the Editor of "SCIENCE."

A friend of mine who is a reliable observer relates an incident which forcibly illustrates the power of parental affection to overcome fear. The gentleman found a nest of young mice and removed them to the ground near by. The mother mouse made her appearance and carried away one of her young and while she was gone the gentleman took the remaining mice in his hand. When the mouse again appeared and could not find her young she seemed to hesitate a moment and then ran up the gentleman's clothes, took one of the young and carried it away. This was repeated until all the young were removed to a place of safety. J. H. PILLSBURY.

SPRINGFIELD, MASS., *Dec.* 27, '81.

BOOKS RECEIVED.

A TREATISE ON COMPARATIVE EMBRYOLOGY, by FRANCIS M. BALFOUR, LL. D., F. R. S. Vol. II. Macmillan & Co., New York, 1881.

An extended notice of this admirable work will appear later, we now simply announce that Messrs. Macmillan are ready to supply the second volume which completes the work, and we feel sure that every Biologist and Anatomist will avail himself of the mass of information included in Professor Balfour's book, which in competent hands must prove one of the most valuable aids to original work in this direction.

ELEMENTARY LESSONS IN ELECTRICITY AND MAGNETISM, by SILVANUS P. THOMPSON, Professor of Experimental Physics in University College, Bristol. Macmillan & Co., Bond St. New York and London. Price $1.25.

AN ELEMENTARY TREATISE ON ELECTRICITY. By JAMES CLERK MAXWELL, Professor of Experimental Physics in the University of Cambridge, England. Clarendon Press Series, Oxford, 1881. Price $1.90. Imported by Macmillan, Bond Street, New York.

Students, and the many practical men who are now studying Electricity with a view to its application to the manufactures and arts, will find that these two books will exactly meet their requirements, in being comprehensive thoroughly practical and reliable. Those who cannot purchase both works, should commence with that by Professor Thompson, and follow with Professor Maxwell's as being more advanced.

The doctrine of the *Conservation of Electricity*, now growing into shape, but here first enumerated under that name, is thoroughly explained in Professor Thompson's book, and may be studied with profit by all interested in the science of electricity. This theory teaches us that we can neither create nor destroy electricity, though we may alter its distribution. According to this view all our electrical machines and batteries are merely instruments for altering the *distribution* of electricity by running it from one place to another, or for causing electricity, when accumulated or heaped together in one place, to do work in returning to its former level distribution.

IDEALITY IN THE PHYSICAL SCIENCES. By BENJAMIN PEIRCE. Messrs. Little, Brown & Company. Boston.

This work by the late Professor Benjamin Peirce is an admirable illustration of the fact, that a man of individuality and sound judgment may pursue the highest scientific work and still find himself in harmony with the religious sentiments of his fellow man.

A great portion of this work is devoted to a review of past astronomical research, and will be read with interest as a reliable exposition written for those who require scientific work explained in simple language.

PHOTOGRAPHIC EXHIBITION.—The substitution of a film of dried gelatin for the thin layer of wet collodion, which the photographer formerly employed as a vehicle to retain the sensitive salts of silver in a suitable condition on his glass plate, has involved considerable alterations in the mechanical appliances used in photography. For out of doors work, or work away from home, the photographer no longer requires to carry what was practically a portable laboratory. Not having to "develop" his pictures on the spot, he need take with him neither dark tent nor chemicals. On the other hand, he must have some provision by which his store of dry plates can be placed, one after the other, in the camera and properly "exposed" without the risk of the slightest particle of light reaching their sensitive surface, other than the light properly directed upon them by the lens. As he wishes to carry an ample supply of plates with him, and as the glass plates themselves make an appreciable burden in a long walk, it is essential that the apparatus for carrying them should be as light as possible; hence have arisen considerable improvement in the camera and its "slides." Again, the increased sensitiveness of the gelatin films makes it possible to give exposures shorter than can be affected by the hand uncapping and re-capping the lens; hence the invention of numerous "instantaneous shutters," by which exposures of a few hundredths of a second can be given, and pictures of moving objects readily secured. These are but instances of the many novel appliances which recent progress in photographic science has originated, and, besides these, there has been, during recent years, many and important improvements in the application of photography to the production of permanent illustrations for books and newspapers. All these varied applications of the art are to be illustrated by an exhibition of photographic appliances which the Council of the Society of Arts announce will be held during January and February next, in connexion with a course of Cantor lectures to be given before the Society by Capt. Abney. Full particulars of this exhibition are given in the *Journal of the Society of Arts* for last week.