in the region of invention secured to one for a limited period as a compensation for having first discovered it, (Vose *vs.* Singer, supra), something in the spirit with which Spanish arrogance once interdicted traffic with the new-found world

It would be impossible, however, within the scope of this article to do more than locate in its proper family this species of property, leaving to the keen decision of practical test the determination of the names and nearness of its kindred. If we have at all resolved intricacies pertaining to the subject, and at least pointed out the paths to further illustration, our immediate object will have been attained, and we shall leave to ampler time the consideration of the numerous incidental questions to which the main interrogatory has given birth.

Correspondence.

The Editors are not responsible for the opinions expressed by their correspondents.

The Galvanic Battery.

MESSRS. EDITORS:—I have been shown a back number of your journal containing a letter from Mr. M. G. Farmer in which he ably and clearly shows that the cheapest source of powerful electric currents of large quantity and intensity is mechanical force, in other words, coal or solar force.

In his letter he makes the following remark: "It is well known that a galvanic battery will perform its maximum work when the external resistance which it encounters is equal to the internal resistance of the battery."

This statement is approximately correct and would be strictly—mathematically—correct did the electromotive force of the battery remain constant. Unfortunately many students draw a wholly wrong conclusion from the above statement which is derived from Ohim's "Theory of Electricity."

I have found when in conversation with many on both sides of the Atlantic that a very general impression prevails that for telegraphic and almost all other purposes the best and most economical results are obtained when the internal and external resistances are equal. That this is not the case will be evident by referring to Ohim's law, viz., "If the electromotive force of the battery be E, the resistance of the battery be B equal internal resistance; the resistance of the circuit, R equal external resistance; the quantity of electricity in motion through the battery and circuit equal Q, then the value of Q will be $\frac{E}{B+R}$

Now if B equal R it is evident that half the work of the battery is expended in overcoming the resistance of the battery itself, producing useless heat, the other half only being available for actual work. If now the question be put "how can a given quantity of zinc and acid be made to produce the maximum amount of external—that is useful work?" it will at once become evident that could the resistance of the battery equal B be reduced to nothing the whole work would be expended in R; in other words could the resistance of the battery be got rid of entirely the whole, that is twice the amount of external work would be produced from the same amount of zinc that was possible when the external and internal resistances were equal. Therefore, in all cases, the resistance of the battery itself should be but a small fraction of the total resistance of the circuit in order to work economically.

There is, however, another reason why the latter should be the case. When a battery works hard the solution near the negative plate is reduced in strength by the decomposition going on and the result is a decrease of electromotive force so that E ceases to be a constant quantity in the above equation.

The variation of E is different in different batteries and the result is that with a Daniel's battery 50 cups whose total resistance is one-twentieth part that of the circuit will produce as much current as 100 cups whose total resistance is equal to that of the circuit. In the former case the consumption of zinc and sulphate of copper will be just one-half that in the latter (local action or waste being excepted.)

The resistance of a telegraphic circuit is varying continually by defective insulation and change of weather, consequently in wet weather when the greatest current is wanted the resistance of the line or circuit is at its minimum and therefore if the battery's resistance be a large fraction of that of the circuit at the very time when the most power is wanted a larger portion than usual of the battery's force is expended in itself. Hence great variability of currents in the circuit.

In conclusion the best, most regular, and most economical results are obtained when the internal resistance of the battery is very small compared to that of the external resistance. CROMWELL F. VARLEY.

Chicago, Sept. 20, 1867.

Case Hardened Iron as Steel.

MESSRS. EDITORS:—Is there any invention or process patented by which iron, by the simple process of case hardening, can be made to answer all the advantages that steel has over iron in a mechanical sense?

I claim to take a piece of good iron and case harden it, and it shall work under the smith's hammer the same as steel, and shall bear annealing, working, and hardening, the same as steel, and do all that steel can do in the form of taps, chisels, hammers, punches, files or any other article that steel is used for. F. C. CURIE.

Lancaster, Pa.

May not our correspondent use the term case hardening for that of converting or cementation? Case hardening, in its results, is, chemically and practically, the same as the ordinary method of converting iron into steel, only not carried so far. The outer portion of the iron, in case hardening, becomes steel, frequently to a measurable depth. If by a quick process of case hardening or converting our correspondent can make good steel from good iron, it ought to be valuable. It is well known that a thin piece of iron, or a small iron wire, can be converted by the process known as cementation. It is quite common among machinists to make large taps of wrought iron, and after they are finished, to case harden them, when, if properly done, they work well.—[EDS.

Lightning Conductors.

MESSRS. EDITORS:—Not having been able to be more than an occasional reader of the SCIENTIFIC AMERICAN, since the collapse of our cause, my attention has not been heretofore called to your article on "Lightning Conductors," in Vol. 16, No. 20, May 18, 1867. As it inculcates an error which is of some practical importance, I beg leave to make the correction.

Speaking of metals, you remark: "The conducting power lies in the surface; a tube is as efficient as a solid rod of the same diameter, and a strip or ribbon, which presents the same amount of surface, is equal in power."

Now, the opinion that the conducting power of metals for electricity is proportional to the extent of surface, is a common popular error. The numerous itinerant lightning-rod men, who perambulate the "area of freedom," are always fortified with certificates perpetuating this physical error. I cannot imagine how such a mistake originated, unless the law of distribution of statical electricity on conductors has been confounded with their conducting power.

No law of electricity is better established, or rests on a more secure experimental basis, than that, for any given metal, the conducting power varies directly as the area of a cross section, and inversely as the length; or, otherwise, conducting power varies as $\frac{\text{Area of cross section.}}{\text{Length.}}$ For the experimental proofs of this law I refer to any of the standard treatises on electricity, as De la Rive's or Becquerel's.

The same law is true, as might have been expected, for Voltaic electricity. In fact, Ohm's law, and the formula which is founded on it, express the same truth. In this form, the accuracy of the law has been tested in the most rigorous manner.

The practical bearing of this law is obvious, as well as important. The "ribbon form" of conductor, which you recommend, will not answer; for the amount of metal, or area of cross section, would not be sufficient. Even your "copper ribon" would, probably, be fused and dissipated under an ordinary stroke of lightning. The rod must have metal enough to carry the electricity; we gain nothing by spreading it out, or otherwise augmenting its surface.

I was glad to see that you exposed the popular fallacy in relation to "insulating the conductor from the building." These glass and horn insulators are totally useless. Those who may be disposed to reject this opinion, will, nevertheless, appreciate the fact, that, when such insulators become wet, they are conductors, and are practically inoperative.

The influence of length on the conducting power, as indicated in the law above given, shows the importance of having the rod as straight as possible; for any increase of length diminishes its conducting power, and, consequently, its efficacy. For the same reason, very long rods should be larger than short ones. ELECTRON.

Science Familiarly Illustrated.

THE ART OF BALANCING.

The feats of skill performed in the circus, which in our boyhood excited our wonder and caused us to regard the actors as beings of a superior order, in after years may be legitimate subjects of study to the thinking mind. Look at the balancing performances. They appear wonderful. One of the "artists" gives a plate a twirl by the hand, throws it whirling into the air, catches it on the point of a sharpened stick, places the other end of the stick on his chin and balances it; then taking up another he repeats the process until he has perhaps six or seven spinning and balancing on head, face, and hands. Another climbs a pole and suspending himself on the top, his body horizontal, another carrying the pole and performer about, accurately keeping the equilibrium of both. Another performer walks erect on a tightened rope or wire, controlling his perpendicular and governing his progress by means of a long pole carried transversely across his body, thus sustaining himself on his narrow base by what is termed the equilibrium of forces. The "flying trapeze" is another exemplification of the art of balancing. The performer requires some judgment, a quick mechanical eye, but mostly constant practice.

Now all these public performances of professionals are equaled, if not surpassed by the successful efforts of the infant just learned to walk. A child of one year old who can just "toddle" about the room, unaided by chairs or the hands of its parents, gives a performance not in any way inferior to that for which people pay their money to witness. Think for a moment what practice—the exercise of judgment and the teachings of instinct can hardly be predicated here—is required to balance a top-heavy weight elevated so high—proportionally—from the base and that so small, and not only this, but to change from one base, or foot, to another rapidly, preserving meanwhile the center of gravity! It is as though a tall tower should be balanced alternately by its base on one side and then the other; and more than that, it has to adapt itself to inequalities of surface and move from one point to another. The slightest excess of momentum by the push or thrust of one point of support, would, according to the laws of mechanics, topple the whole structure over, and the line of gravity, passing beyond the base it would inevitably come disastrously to the earth. Yet in the case of the infant just beginning to walk—of course entirely ignorant of the laws of gravitation—the slight practice to which it has been subjected proves sufficient for it to rival the performances of those who "astonish the natives" in public entertainments.

With all our knowledge of mechanical contrivances, we have never yet succeeded in reproducing this alternate balancing in mechanism. The walking doll is a very clumsy imitation, or simulated attempt at the ordinary process of walking, so common that we do not notice it. When machinery, built of rigid metal, can be made to imitate, successfully, the ordinary movements of the animal organism, we may consider a new door opened to mechanical inventors, but it is doubtful if we shall ever arrive at such a stage of mechanical perfection as this.

Concerning Man.

Wonders at home by familiarity cease to excite astonishment; but thence it happens that many know but little about the "house we live in"—the human body. We look upon a house from the outside, just as a whole or unit, never thinking of the many rooms the curious passages, and the ingenious internal arrangements of the house, or of the wonderful structure of the man, the harmony and adaptation of all his parts.

In the human skeleton, about the time of maturity, are 165 bones.

The muscles are about 500 in number.

The length of the alimentary canal is about 32 feet.

The amount of blood in an adult averages 30 pounds, or full one-fifth of the entire weight.

The heart is six inches in length and four inches in diameter, and beats seventy times per minute, 4,200 times per hour, 100,800 per day, 36,772,000 times per year, 2,565,440,000 in three score and ten, and at each beat two and a half ounces of blood are thrown out of it, one hundred and seventy-five ounces per minute, six hundred and fifty-six pounds per hour seven and three-fourths tuns per day. All the blood in the body passes through the heart in three minutes. This little organ by its ceaseless industry.

In the allotted span
The Psalmist gave to man,

lifts the enormous weight of 370,700,200 tuns.

The lungs will contain about one gallon of air, at their usual degree of inflation. We breathe on an average 1,200 times per hour, inhale 600 gallons of air or 24,400 gallons per day. The aggregate surface of the air cells of the lungs exceeds 20,000 square inches, an area very nearly equal to the the floor of a room twelve feet square.

The average weight of the brain of an adult male is three pounds and eight ounces, of a female two pounds and four ounces. The nerves are all connected with it, directly or by the spinal marrow. These nerves, together with their branches and minute ramifications, probably exceed 10,000,000 in number, forming a "body guard" outnumbering by far the greatest army ever marshaled!

The skin is composed of three layers, and varies from one-fourth to one eighth of an inch in thickness. Its average area in an adult is estimated to be 2,000 square inches. The atmospheric pressure being about fourteen pounds to the square inch, a person of medium size is subjected to a pressure of 40,000 pounds! Pretty tight hug.

Each square inch of skin contains 3,500 sweating tubes, or perspiratory pores, each of which may be likened to a little drain-tile one-fourth of an inch long, making an aggregate length of the entire surface of the body of 201,166 feet or a tile ditch for draining the body almost forty miles long.

Man is made marvelously. Who is eager to investigate the curious, to witness the wonderful works of Omnipotent Wisdom, let him not wander the wide world round to seek them, but examine himself. "The proper study of mankind is man."—*Cin. Journal of Commerce.*

Burns.

In regard to the treatment of burns there is a great diversity of opinion, scarcely any two surgeons agreeing as to the remedies. All of them are doubtless valuable, but there is one which has a great reputation, carron oil, limewater, and linseed oil. The great objection to it is its offensive odor, rendering an entire ward disagreeable. When the burn is very superficial, simply inflaming or vesicating the part, covering it up with flour, and then placing a layer of cotton over it so as to exclude the air, makes a very comfortable dressing. Another method consists in applying cold water, and another warm water covered with oiled silk and a bandage. Lard, deprived of salt, and simple cerate make pleasant applications. The profession is indebted to Prof. Gross for the introduction of white lead and linseed oil in the treatment of burns. It is one of the very best applications which can be used, effectually excluding the air, and being always grateful to the patient. In all cases, no matter whether merely the skin or the deeper structures are involved, white lead rubbed up with linseed oil to the consistence of paste or paint, and placed on with a brush, will be found productive of great relief. There does not appear to be any risk from the constitutional influence of the lead, though it has been suggested, to counteract any tendency of this kind, that the patient should take occasionally a little sulphate of magnesia.—*Medical and Surgical Reporter.*

EXTRAORDINARY COINCIDENCES.—The diameter of the earth multiplied by 108 gives the diameter of the sun; the diameter of the sun multipled by 108 gives the mean distance of the earth from the sun; and the diameter of the moon multiplied by 108 gives the mean distance of the moon from the earth.