of a spring that becomes more rigid as it is extended or compressed out of its normal shape. My friend Thomas Meehan informs me (Dec. 17, 1889) that he has "observed a case where the interior hollow makes an annual layer of bark equally with the exterior," and he is of the opinion that "it is by the decay of the outer layer of this inside course of bark after several years that the knob becomes hollow." If this habit is general, it is an admirable means of forming and of preserving undecayed, at the smallest cost to the tree; a living elastic strengthener at the forking of the roots When in a hurricane the great tree rocks back and forth on its base, and with its immense leverage pulls upon this odd-shaped wooden anchor, instead of straightening out in the soft material, as an ordinary root might, thus allowing the tree to lean over and add its weight to the destructive force of the storm, it grips the sand as the bower-anchor would do, and resists every motion. The elasticity at the point of junction allows one after another of the perpendicular flukes attached to the same shank to come into effective action, so that before being drawn from the sand or ruptured the combined flukes present an enormous resistance.

The drawing opposite I have made for the purpose of simplifying the discussion. It shows an hypothetical cypress with two roots of the same length and diameter,— one with knees, the other without them. The superior strength of the stiffened root would seem sufficiently evident; but, with the view of obtaining the judgment of a mind thoroughly trained in questions of this nature, I submitted the drawing to my friend, Charles Macdonald, late director of the American Society of Civil Engineers, whose eye has been accustomed to estimating the value of strains in structures by an active experience of twenty-five years, and who has just finished the largest drawbridge in America, at New London. Mr. Macdonald ageeed with me that the root B, which is trussed with the knees C and C′, would very largely exceed in capacity for holding the tree firmly in yielding material the root A, which is similar but destitute of knees. This greatly increased security against destruction by storms is, I think, a sufficient advantage to account for the existence and maintenance of an organ that draws so slightly upon the vitality of the plant.

It is proper to record here another observation that may explain the existence of the elevated, narrow point which the knee sometimes develops, and which rises higher than the curved growth that would be necessary to secure the maximum resistance to compression and extension. The home of the cypress is in broad level river-margins subject to periodic overflow, where hundreds of square miles become covered with a shallow bed of slowly moving water, or in basin-like depressions, sometimes of vast extent, where from time to time water rises above the level of the horizontal roots. Then these stake-like protuberances, rising into and through the current formed by the drainage or by the winds, catch and hold around the roots of the parent trees many thousand pounds of "plant-food" in the form of reeds and grass, or small twigs among which dead leaves become entangled. The tree that exclusively possesses this source of nutrition is at an advantage over all others in the neighborhood; and the higher these attenuated "drift-catchers" rise in the stream, the more drift will they arrest, for the highest stratum of water is richest in float. The theory that some distinguised writers have suggested that the knee is a factor in the aëration of the sap and that the tree's death is prevented by such aëration taking place in the upper portion of the knee during periods of high water, would seem to need careful experimental confirmation. Where Nature forms an organ whose purpose is to preserve the life of the individual, she takes special care to adapt such organ to the function it is depended upon to perform. In this case the rough, dry bark of the knee offers a most imperfect means of access for the oxygen or other gases of the atmosphere to the interior vessels of the plant, and instead of presenting broad surfaces of permeable membrane, formed for transmitting elastic fluids, at its upper extremity the protuberance becomes more narrow, and presents less surface as it rises, so that when, during periods of high water, the life of the tree is most jeopardized, the life-saving organ attains its minimum capacity. In the presence of this manifest want of adaptation, it also seems important for the acceptance of the aërating theory, that some one should experimentally show that the aërating organ of the cypress really aërates to an extent sufficient to make it of material advantage to the plant. The chemical theory of the cypress knee seems to be but a revival of the elaborate hypothesis of Dickinson and Brown, published in their memoir on *T. distichum* in the *American Journal of Science and Arts*, in January, 1848. These industrious observers discard the mechanical theory entirely, and consider both the spongy knees, and, strangely enough, even the spreading base of the tree, as organs of communication with the air, forgetful that the successful and most celebrated lighthouse in the world—the Eddystone—was avowedly modelled after a similar spreading tree-base for the purpose of withstanding the storm shocks of the English Channel. By means of a curious drawing they show how the swollen portions of the base rise "to the top of the highest water level, which must, in some instances, attain an elevation of at least twenty-five feet;" thus continuing the functions and the structure of the knees, "up the body of the tree to the atmosphere."

It was long ago observed that no knees are developed when the tree grows in upland upon a firm bottom, in which ordinary simple roots can obtain in the ordinary way the hold necessary to resist overturning forces, and where there is no stratum of water to transport food. So conservative is Nature, that she reverts to an original or adopts a simpler form of root even in a single generation, if the need for the more complicated arrangement ceases to exist.

Finally, I may perhaps be permitted to add an observation regarding the roots of other trees that trench upon the same soils affected by the cypress, and often take advantage of the anchors it sets so boldly in treacherous bottoms. These trees project their cable-like, flexible roots in every direction horizontally, interlacing continually until a fabric is woven on the surface of the soft earth like the tangled web of a gigantic basket. Out of this close wicker-work, firmly attached to it, and dependent for their support upon its integrity, rise the tree-trunks. Thus slowly, and by a community of growth and action, a structure is formed that supplies for each tree a means of resisting the storms. Such communities of trees, provided with ordinary roots, advance against and overcome enemies where singly they would perish in the conflict. The cyclone, the loose sand, the morass,— these are the enemies they contend with, as it were, in unbroken phalanx, shoulder to shoulder, their shields locked, their spears bristling against the foe; but the graceful plumed cypress, the knight-errant of the sylvan host, bearing with him his trusty anchor,— the emblem of hope,— goes forth alone and defiant, afar from his fellows, scorning the methods of his vassals, and planting himself boldly amid a waste of waters, where no other tree dare venture, stands, age after age, erect, isolated, but ever ready to do battle with the elements. Twenty centuries of driving rain and snow and fierce hurricane beat upon his towering form, and yet he stands the there, stern, gray, and solitary sentinel of the morass, clinging to the quaking earth with the grasp of Hercules, to whom men were building temples when his wardenship began.

ROBERT H. LAMBORN.

THE GESNER RUST-PROOF PROCESS.

IN *Science* of Dec. 27, 1889, we printed a report by Professor Haupt on the hydrogen process of protecting iron against corrosion. Since that report was made, a long and exhaustive series of experiments have been carried out by Dr. G. W. Gesner of this city, with the result of greatly improving the process, making it more uniform in its effects, simpler in operation, and less expensive in cost. The general features of the process are the same as described in Professor Haupt's reports, but the operations have been so simplified that the process may now be worked on a commercial scale by any workingman or laborer of ordinary intelligence, after a little practice and instruction.

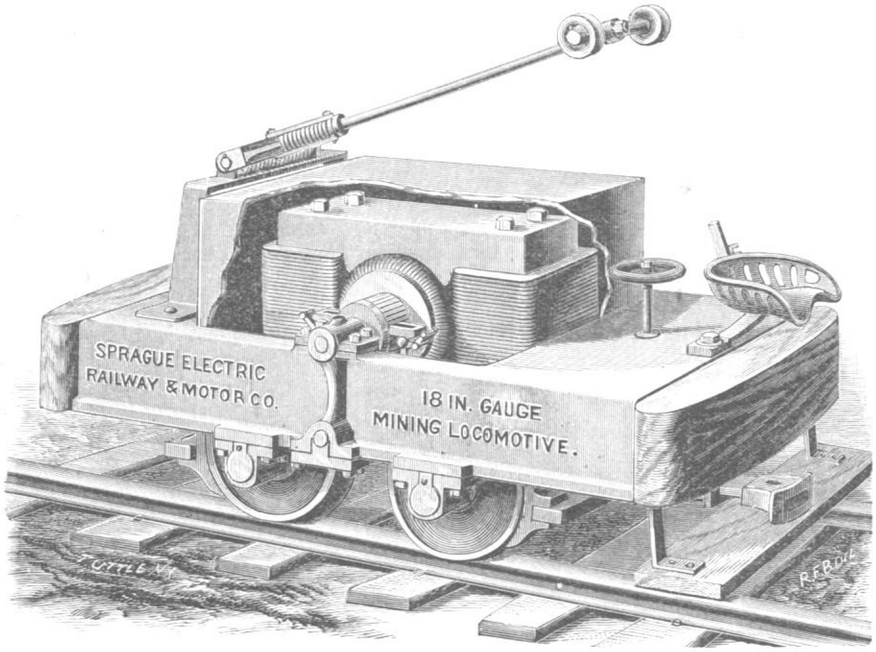
Dr. Gesner has now in constant operation in Brooklyn a plant for the treatment of iron and steel by this process. As the plant is small at present, attention is mainly given to small articles, such as steel and iron shingles for roofing, builders' hardware, artistic ironwork, furniture springs, polished parts of steam-engines and other machinery, boiler-tubes, nuts and bolts, water-meters, steam-radiators, and similar easily handled articles; but the intention is to apply the process, on a larger scale, to architectural and structural iron and steel, telegraph wire, and probably to iron and steel plates for boiler construction, ship-building, and similar uses.

As described by Professor Haupt and Dr. Gesner, this process does not produce a magnetic oxide upon the surface of the metal, as is the case in other processes for making iron rust-proof, nor does it alter the dimensions of the articles treated. It changes the body of the surface of the metal into a compound of hydrogen, iron, and carbon, which is designated a double carbide of hydrogen and iron, as determined by analysis. Being an integral part of the metal, it cannot scale or peel off; and it prevents indefinitely the rusting of the metal through exposure to the weather, steam, damp earth, etc. It is also found that cast iron is to some extent annealed in the process, and its pores filled, so that thin cast-iron pipe which before treatment would leak at five pounds pressure per square inch, will stand a pressure of fifty pounds without leakage after undergoing the process. It also improves the quality of steel.

The following is the report of Barton H. Coffey, M.E., of the Henry Warden Iron Works, Philadelphia, on the results of tests to determine the effect of the hydrogen treatment on the physical properties of iron and steel:

''These tests were determined upon to decide if the hydrogen anti-corrosive treatment had any adverse effect, and if so to what extent, upon the strength and resilience of wrought iron and steel suitable for boiler, ship, and bridge purposes. Five test-pieces of iron were cut from a single plate one-half inch thick, and five more similarly from a three-eighth inch steel plate. These were machined to suitable sizes for the standard eight-inch test-piece, giving a section of about .71 of a square inch for the iron and .51 of a square inch for the steel. Three of each of these sets were forwarded to Dr. Gesner for treatment, who retained one and returned the remainder. The tests were made with a 200,000-pound Olsen machine, and the measurements with Brown & Sharpe micrometer gauges, and are believed to be accurate.''

The results were recorded upon test-blanks, which it is unnecessary to reproduce here, it being sufficient to summarize the results as given in the report. ''The pieces were gauged both before and after treatment, and showed no change. The tests show practically no effect whatever upon the iron, with the exception of a slight decrease in the elongation. As the area is not reduced, it would be impossible, without further evidence, to say whether or no the ductility were affected. At any rate, the ductility being so low, this small reduction, if proved to exist, would be of comparative unimportance in affecting the value of the metal. The steel is benefited. The annealing undergone during the treatment has softened it to some extent. It has lost about five per cent in strength, but gained five per cent in elongation. This metal, as originally, would not have come up to specifications, being insufficient in stretch. The treatment has not reduced the tensile strength below the assigned limit, at the same time it has brought the elongation up to requirements. Pieces of both iron and steel were bent cold to an angle of forty-five degrees without showing any fracture or scaling of the treated surface.''



THE STOREY ELECTRIC MINING LOCOMOTIVE.

In conclusion, the report says, ''The hydrogen process does not affect the value of iron and steel for engineering purposes. The treatment benefits steel by the annealing undergone in the process. The treated surface possesses elastic properties of the highest value.''

ELECTRIC LOCOMOTIVE FOR METAL MINES.

WE show in another part of this issue a view of a new electric rotary diamond drill, manufactured by the Sprague Electric Railway and Motor Company of New York, which has shown gratifying results in the tests to which it has been put, and which promises to fulfil a long-felt want in electric mining. On this page we show another special electric mining application; i.e., an electric locomotive. This locomotive is simple, powerful, and compact, and is built with special reference to the rough usage and arduous duties required of such a machine.

The gauge of the accompanying locomotive is eighteen inches, but it can be accommodated to any gauge in ordinary commercial work. In order to protect the machine from damage, all the working parts are completely boxed in, as shown in the view. The speed of the motor is under complete control by a switch which throws the winding of the field into