enter the liquid, and others (those which make an angle greater than the extreme one, F, with the perpendicular to the point of incidence) will undergo a total reflection and light up the lower portion of the reticule, while the upper portion, which receives no luminous ray, will remain dark. The line of separation of these two regions will vary with the limiting angle, and, as this latter depends upon the index of refraction, it may be readily seen that the position of this line will give the index of the liquid submitted to experiment if the apparatus is properly graduated. We shall, then, read upon the scale the division through which this line passes, and this latter will be so much the lower in proportion as the index, n, is greater, since F increases at the same time with n. So much for liquids.

With solids the principle is the same, and the operation is as follows: We place a plane and polished part of the object against the lens and interpose a little liquid of an index higher than that of the solid, since a total reflection cannot occur on the surface of separation of two substances unless the luminous rays are passing from one refracting medium into another that is less so. Upon looking into the apparatus, we shall see two lines—one corresponding to the index of the solid, and the other to that of the liquid. It is the former of these whose position must be read upon the graduated scale. It would be impossible to confuse the two, since the liqud used is determined in advance.

In order to graduate the apparatus, the indices of the different liquid or solid substances are accurately determined, and then it is ascertained what divisions of the reticule correspond thereto. After this a table is prepared that gives the index corresponding to each division.

In giving the method employed with solids, we remarked that the immersion liquid must have an index greater than that of the substance to be studied. For bodies of low index, such as fluorine, oil or benzine may be used. For those of a higher index, it is well to employ dibromated naphthylphenylacetone. This substance, which was discovered by Mr. L. Roux, has an index of 1·7, and may consequently be used for almost all solid bodies, for there are but a few whose index exceeds that of this. Mr. Bertrand in using it adds to it a few drops of bromated naphthalene, which lowers its index but slightly and renders it completely liquid.

In order to fully appreciate the real value of this new instrument, and to understand its advantages and simplicity, it will suffice to recall the "Newton method" that is generally employed for measuring indices. Here. if it is a solid body, we give the specimen the form of a prism, and measure the angle, A, of the latter, and obtain the value, D, of the minimum deviation. After this we calculate the index, n, by means of the formula

$$n = \frac{\sin \frac{D+H}{2}}{\sin \frac{A}{2}}$$

These operations necessitate the use of complicated instruments, certain notions of mathematics and physics, and lengthy calculation. With liquids the difficulty is still greater; moreover, this method cannot be applied unless we have on hand a sufficient quantity of the substance to use at our will.

The refractometer, on the contrary, furnishes the index upon a simple reading, and without the necessity of breaking or destroying the object. It gives the two first decimals accurately, and even the third with in about two or three units—this being a sufficient approximation in many cases. It can be used with advantage by jewelers and lapidaries, since it permits of distinguishing genuine from imitation stones, owing to the difference in their indices.—*Le Genie Civil.*

APPARATUS FOR DISTRIBUTING SULPHIDE OF CARBON.

When sulphide of carbon for destroying the phylloxera is not distributed by a plan devised for the purpose, it is poured or injected into the ground by various devices that permit of a given quantity at a time being dosed out.

Fig. 1.

The best known injecting apparatus consists of a can of a size such as to render it portable, and in the center of which there is a pump, which, at every piston stroke, sucks up some of the liquid and injects it into a hole made for the purpose. In most cases the force pipe is strengthened, and tapers to a point, so as to serve as a sort of dibble for making a hole in the ground. In all these apparatus the pump is not visible, and it is not easy to inspect the internal parts. Moreover, an exact portioning out of the liquid is not secured.

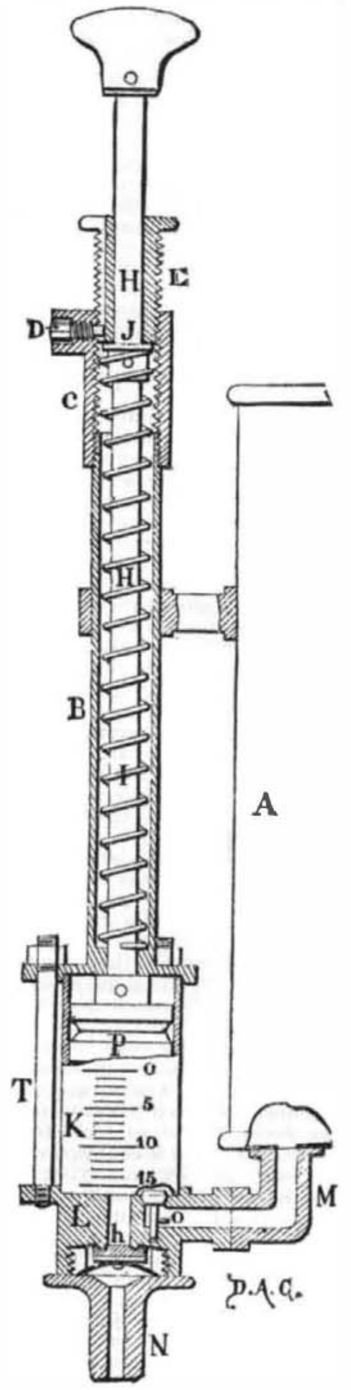

Fig. 2.

Mr. A. Lafare, of St. Marcel, France, has devised quite a simple apparatus, which is herewith figured in perspective in Fig. 1 and in section in Fig. 2. The tools for forming the holes are shown in Figs. 3 and 4.

The cylinder, B (Fig. 2), in which the piston rod moves, is provided below with a flange which is connected by bolts, T, with the piece, L, that contains the suction valve, o, and the force valve, h. The pump chamber, K, is inclosed between the two pieces, B and L, and is made of glass, so that the liquid and piston may be seen. The graduation that it carries shows the quantity of sulphide injected, according to the different positions of the piston, P. The latter consists of two disks of hot-pressed leather, and is held at the upper end of its travel by a spring, I, which rests below upon the bottom of the cylinder, B, and which above bears against the flange of a socket, J, keyed to the rod, H.

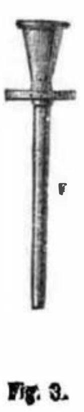

Fig. 3.

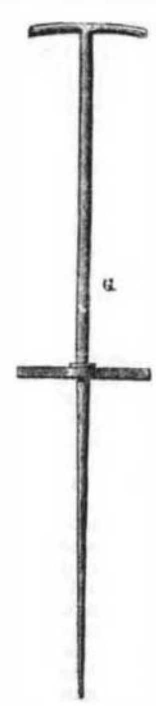

Fig. 4.

The height to which the piston rises, as well as the quantity of liquid sucked up and ejected, is varied by means of an arrangement fixed to the upper part of the cylinder, B. Upon the threaded piece, C, screwed on to the top of the cylinder, B, there is screwed a long nut, E, traversed by a groove, with which engages the end of the screw, D, that serves to fix the nut. According as this latter is screwed up or unscrewed one or two turns, the position of the piston will vary, by one or two divisions, each thread of the nut, E, corresponding to one graduation of the cylinder, K. The head of the screw, L, is square, and is countersunk. It can be moved only by a key like that of a clock, and so, if the workman is not in possession of this key, he cannot vary the amount of liquid injected.

The piston rod carries a button which is acted upon by the palm of the hand, while the fingers bear against two small projections on the piece, C (Fig. 1).

The measured liquid is injected through the tube, N, to which is adapted the nozzle, F (Fig. 3), which is inserted into the hole in the ground made with the tool, G (Fig. 4). This apparatus has certain advantages over all other known systems, all the parts being visible and accessible, and easy to verify and repair. Moreover, the measuring is very accurate, the piston, P, always reaching the bottom of the cylinder and forcing out every bit of the sulphide sucked in, and, in rising, stopping at various heights, according to the position of the nut, E, thus varying the quantity of liquid injected. This mode of injection is simpler than that in which a sulphureting plow is used, but is neither so expeditious nor so effective, a large part of the sulphide being injected to too great a depth to act. —*Chronique Industrielle.*

GAS ENGINEERING AND MODERN SCIENCE.*

By Denny Lane.

It is by some people imagined that our branch of engineering is not so scientific as those practiced by our friends the mechanical, or our generous hosts the civil engineers. I propose to show how all branches of physical science are connected—most of them very intimately connected—with our industry. In doing so, I propose to take a broad view of modern science—to show how all its departments are so closely linked together that they practically become one.

All our knowledge of material nature is communicated to us by the senses. These stand as janitors at the portals ready to receive every message sent to us within from the world without. In most cases—perhaps in all—these messengers, who bring us tidings of weal or woe, have no independent existence; they are but the waves of that imponderable ether that fills all space, or of the crasser air in which our bodies are bathed, or the vibrations of the denser liquids and solids that we can more easily feel and weigh and handle. The aggregates of these vibrations we call the forces of nature; and by them all her wonderful actions and interactions are regulated. Swift messengers they are, most of them leaving "the herald Mercury" far behind in the race—from the wave of sound that travels over less than a quarter of a mile in a second to the ray of light that covers 186,000 miles in the same time. But more wonderful than the speed is the deftness of their flight. A large multitude of men, to be counted by thousands, are assembled by night looking up at a hemisphere powdered over with stars to be counted by myriads; yet each "bright particular star" sends its skein of rays to each and every eye in that vast multitude—skeins that never ravel, never tangle—speeding in every possible direction without haste, without rest. With inconceivable swiftness, there is yet no hurry; with inconceivable number, there is no confusion. Not one of the swift messengers jolts his neighbor from his path. Or look at garden and woodland. Not only every petal and every leaflet, but every microscopic point of each sends forth its troop of heralds, each wearing a tabard of its own color; each, without obstructing his fellows, fleeing to deliver his embassy to the brain. Or take an orchestra. Each instrument utters some one or more notes; but each note, again, is made up of many sounds—the ground tones and the overtones—the partials few or many. From each instrument each sound speeds to each ear in a vast audience. They also cross and recross each other, but never jostle. Again no hurry, no confusion. In opener or more serried ranks, swiftly, but with measured paces, they speed to bring each its message to the mind of man.

Wonders are these, that grow more wonderful the more we ponder over them, in the infinite variety, power, and beauty of each. But how must our admiration increase when we come to think that all these mighty powers are one; that each can exist only as the product or the cause of some other; that each may be converted into another, but then ceases to exist in its previous form; that all this apparent complexity is founded upon absolute simplicity—upon a complete oneness; that the power which marries the unsubstantial elements, and unites them into the drop of water; that the power which compels gold to become as fluid as water, or dissipates the solid rock into thinnest air; that the power which, in a moment, sends our words across an ocean so broad that "the lightning's wing sinks half way o'er it like a wearied bird;" that the power which, from trumpet, or from timbrel or psaltery, can arouse or allay our passions; that the power that opens our eyes to feast on the beauty of art and nature, and enables us to look into the face of our fellow-man—that all these great and beneficent powers are really one; that they are all translations into different tongues of the one great central organic law which governs the universe. This law is that the sum of all the forces is a constant quantity—that, therefore, energy can neither be created nor destroyed. It may assume different forms, just as a ponderable body may exist in the solid, the liquid, or the gaseous form. As with the latter we can neither add nor take away a grain of its weight, so with the former we can neither increase nor diminish by a single unit one of those microscopic waves which sometimes scarcely exceed in length the hundred-thousandth part of an inch, and in duration do not reach the millionth part of the millionth of a second.

I fancy I hear some one murmur, "Wonderful, truly! But what has this to do with us or our affairs?" I an-

* From the Inaugural Address before the Gas Institute, June 8, 1886.