THE NIVET APPARATUS FOR TESTING BUILDING MATERIALS.

The testing of building materials is a matter of undoubted importance. The solidity of our structures and our safety may depend upon the care with which such testing is effected. Learned societies and governments themselves have occupied themselves with this important question, and commissioners have been appointed for a study of the conditions under which the tests should be made, in order, if possible, to succeed in unifying the methods employed, and in obtaining concordant results. The tests to which the materials must be submitted require the bringing of great stresses into play. The apparatus used are inconvenient to maneuver, are of great weight and are high priced, and so trial tests are not made so frequently as might be desirable.

In 1895, Mr. Nivet presented to the meeting of the French Association for the Advancement of Sciences an apparatus for testing building materials (other than metals) that constitutes a genuine portable laboratory, and that seems to us to be destined to render valuable services in the testing of lime, cement and stone in workyards. The entire mechanism is contained in a box measuring 13 × 20 inches, and three inches in height, in which also are placed the moulds, F F (Fig. 1), necessary for the preparation of the test pieces. The weight of the apparatus with all the accessories does not exceed 88 pounds.

The measuring device is a Regnier dynamometer (Fig. 2). This instrument consists of an elliptic steel spring, R, upon one branch of which is fixed a divided dial, C. This latter, which our draughtsman has supposed to be transparent in order to allow the details of the parts to be seen, is provided with a needle, a, whose axis carries a toothed wheel, and which meshes with a rack, c, that slides freely in its mounting. One end of this rack is in contact with the spring when the needle is at zero, and the spring is not bent. When the short axis of the spring is compressed through a pull upon the long axis directly, or upon the lugs, e e, the spring exerts a thrust upon the end of the rack, and consequently causes the needle to revolve by a certain number of degrees proportionate to the distortion, that is to say, to the force to be measured.

Since the rack is not fixed to the spring, the needle, when the latter expands, remains in the position that it occupied at the moment at which the force was suppressed or simply diminished. It thus indicates the maximum value of the force that has been applied. Before beginning an experiment it is evidently necessary to place the needle at the zero of graduation by hand. When the short axis is acted upon directly, the dynamometer is very sensitive. It is much less so when we operate by traction upon the long axis. The dial carries two divisions corresponding to these two methods of using the instrument. The figures inscribed upon the dial represent a fifth of the real stresses in order to render it possible to read the weights per square centimeter that determine the breakage of test pieces of five square centimeters section. The results given by test pieces of different section are calculated by means of multiples, a table of which is affixed to the box containing the instrument.

In Mr. Nivet's apparatus, the upper lug of the dynamometer, which acts upon the lower branch of the spring, is hooked to a second lug pivoted through a knife edge upon a lever L (Fig. 1), which is itself pivoted at O upon the frame of the machine. This lever, L, may be rendered stationary by means of a nut, v. The lower piece is connected, according to the operations to be effected, with different parts, as we shall see further along.

The traction is effected by means of a screw, V, maneuvered from the exterior of the box by a handle. This screw carries along the jaw, M, as well as the lugs, E E. It is through the intermedium of this jaw and of these lugs, E E, that the traction is transmitted to the test pieces.

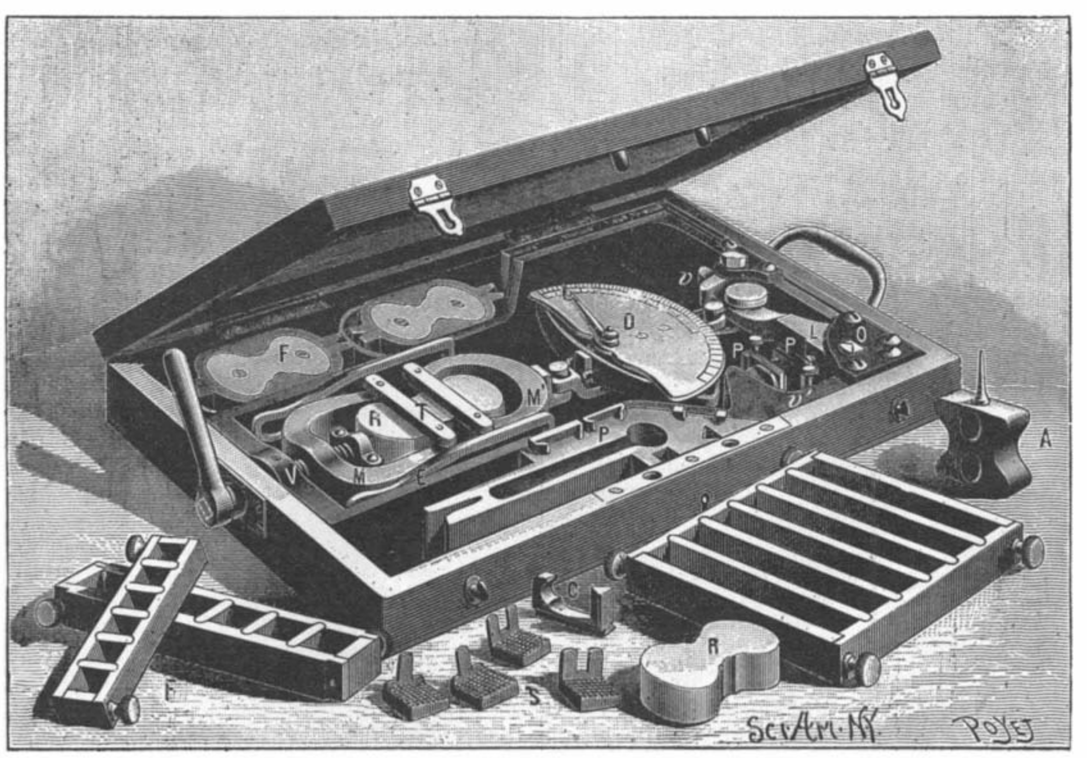


Fig. 1.—NIVET APPARATUS FOR TESTING BUILDING MATERIALS.

The dynamometer and the different parts of the apparatus rest upon a horizontal cast iron frame that forms a part of the box. The weight of these different parts and of the test pieces themselves is thus annulled and has no influence upon the results.

The apparatus may be used for two series of tests. The first series comprises the traction and compression tests used in laboratories.

Traction.—The test pieces, R, of the materials to be examined have the form of a figure 8, the constricted part of which has a section of 5 square centimeters. In order to perform the experiment, the lever, L, is rendered stationary by means of the nut, v (Fig. 1). The dynamometer is attached at its lower part to the jaw, M'. The test piece is placed between the two jaws, which embrace its periphery. Each jaw is strengthened by a crosspiece, T. Upon slowly revolving the screw, v, a traction is effected whose value at every moment is given by the needle of the dynamometer. When the breakage takes place, the spring abruptly expands, but the needle remains in place and indicates the breaking stress. As the points of suspension and jointing are in a line with the axis of the screw, the stress is transmitted

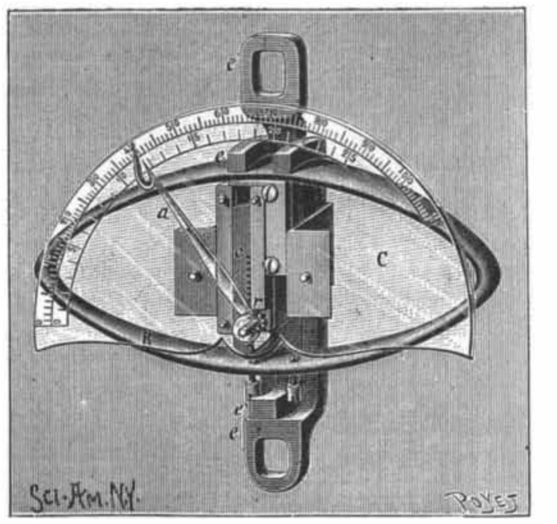


Fig. 2.—DETAILS OF THE DYNAMOMETER.

solely in this direction, so that the test piece is submitted to no flexional stress.

Compression.—The experiments in crushing are made with tubes whose section is 5 square centimeters, 2·5 square centimeters, or, better, 1 square centimeter. The lever, L, is rendered free (Fig. 1) and the two jaws, M and M', are connected by the metallic piece, A, which has the form of a figure 8.* The test piece is placed between the two plates, P P, one of which rests against the cast iron frame of the box, and the other is movable with the lever, L. The movable plate is placed at such a point of the lever that the pressure shown by the dynamometer shall be multiplied by 5. The plates engage with the frame and lever by conical points that enter conical seats in the larger center. They are, therefore, capable of taking on a certain amplitude of motion, and are not necessarily parallel, like the plates of hydraulic presses. This arrangement permits of correcting the irregularities in the moulding of the test pieces. In employing the press, we have almost always two coefficients of crushing, one called the beginning of crushing and the other the final crushing. The first corresponds to the breakage of too long an edge, and the other is obtained upon a cube already broken and incomplete.

In the Nivet apparatus, the needle has but a single stoppage point, which corresponds exactly to the weight that has caused the rupture of equilibrium of the molecules of the compressed solid. Upon continuing to work the screw, we crush the test piece without the needle making a greater pressure. On the contrary, the pressure has diminished, as may be ascertained, if, after having registered the indications given by the needle, we endeavor to push the latter back with the finger. It will stop at a much lower pressure. The lever apparatus completely crushes the solid experimented upon, unless the continuous action of the weight be arrested by an obstacle. The dynamometer, on the contrary, automatically preserves the test piece against such action.

This delicacy of operation permits of studying the clearages produced by the crushing. Such clearages generally separate from the cube of the pyramids that have the free faces as a base and a quarter of the sides as a height. As the dynamometer is capable of indicating a pressure of 1,210 pounds, and as the lever multiplies the stress exerted by 5, it is possible to produce between the plates a compression reaching 4,950 pounds that are distributed over the cubes of the different dimensions indicated. The cubes are exactly centered by a play of nuts that are separated when the test pieces are grasped by the plates, the screw having begun to act.

The second series of tests is made by employing a single test piece in the form of a prism with a square base of $\frac{3}{4} \times \frac{3}{4} \times 4$ inches, upon which the apparatus permits of obtaining as many as nine breakages—one by flexion, two by traction, two by shearing and four by compression.

Flexion.—The breakage test by flexion is made upon the entire test piece. The lever, L, is rendered stationary (Fig. 1); the jaw, M', is suppressed; the test piece is grasped at its two extremities by the lugs, E E, kept at 4 inches from each other, while a piece, C, fixed to the dynamometer and guided by a slide in the frame bends it exactly at the middle. The way in which the breakage occurs shows the defects of the test pieces in homogeneousness when they exhibit dissymetrical breakages.

Traction.—The test piece is divided into two equal fragments by the flexion test. Each of these serves to effect a traction test. To this effect, the dynamometer is connected with the jaw, M', and the small prism is held between two clamps, S. Each of these consists of two quoins connected with each other by a slide at right angles with the parallel faces that grasp the prism, and the inclined faces of which engage between the branches of the jaw. When the screw is revolved, these inclined faces tend to squeeze the faces of the prism so much the more in proportion as the traction is stronger. They thus prevent a sliding, and a breakage by pulling soon takes place. It must be remarked that the pressure exerted upon the solid by the parallel faces of the clamps is at right angles with the axis of traction and consequently has no influence upon the result of the breakage by traction. Moreover, such pressure is relatively feeble, the angle of the inclined planes being very small and the surface that serves to transmit such stress being relatively wide. As the coefficient of breakage by crushing is about ten times that of traction, the pulling occurs before the compression of the prism in the clamps has been able to reach an important value. Such compression can therefore have no influence either upon the actual test or upon the ulterior experiments.

Shearing.—After these tests, the prism is divided into four fragments, the two longer ones of which are selected for experiments in shearing.

The lever, L, is rendered free (Fig. 1), and the two jaws, M and M', are connected by the piece, A. The prism is placed in the square space of a vertical cylinder, H, inserted in the frame of the apparatus in which it revolves with slight friction. The shearing is done by an edge of the lower face of the lever operating through its center. This face moves upon the upper plane that terminates the cylinder carrying the test piece. The shearing will therefore be done exactly according to this plane of insetting of the solid—a condition that we believe is realized only in this apparatus.

Compression.—If we neglect the fragments detached by shearing, we still have four segments of a prism that may be used for tests in crushing.

These tests are made as with the cubes by placing the solids between two plates, P P, that have been previously provided with two punches or disks of metal three-quarters of an inch in width. There is thus seized between the punches a cube inscribed in the prism. Under the pressure of the punches, when the crushing occurs, the clearages are the same as those obtained with the cubes. The same pyramid is separated in carrying with it the part of the prism that exceeds the width of the punch. There is the same clearage,

* This piece carries a cylindrical rod having a section of 1 square millimeter, say 1·13 millimeter in diameter, which carries a Vicat needle for setting tests.

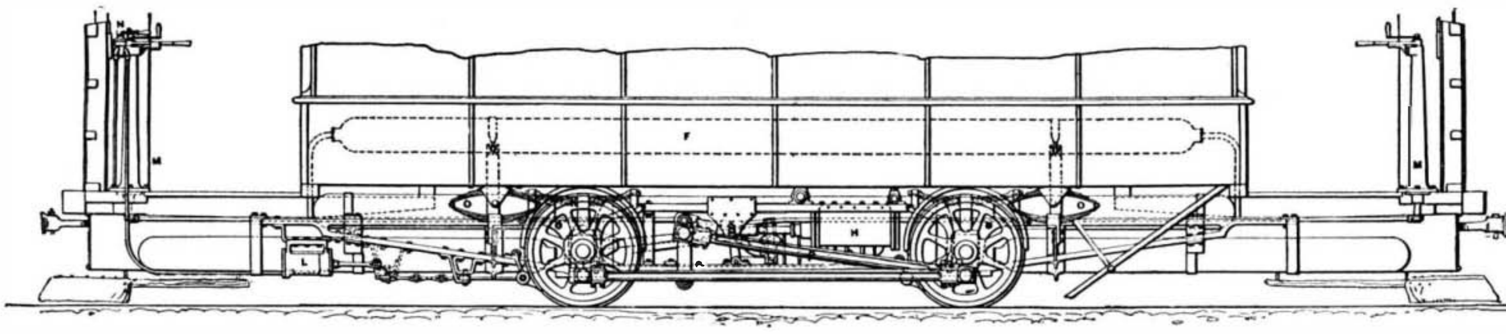
consequently the same work, and the same coefficient. The four segments behave like cubes, and, if the material is homogeneous, give results that are sensibly equal.

This second series of tests has the great advantage of permitting all the operations to be effected upon the same solid. One can thus study the relations that may exist between the various coefficients that result therefrom. The precision of the apparatus, in fact, permits not only of verifying the coefficients of quality required by the conditions of a contract for supplies, but also of effecting true scientific researches. Through this apparatus Mr. Nivet has been able to indicate a few laws of the resistance of materials called nonelastic. A study of such work would exceed the limits of this article. We shall add that the tests upon traction and shearing give figures proportional to the sections upon which we operate, while the tests upon crushing give more complex results. In this latter case the coefficient is proportional to the section when the height of the solid tested is equal or superior to the side of the base; but it increases as soon as the ratio of the height to the side of the base diminishes, and becomes infinitely great when the height is very feeble with respect to the base—which is precisely the case with mortar joints. The tests upon crushing must, therefore, be made upon solids whose height is equal to or greater than the side of the base.—La Nature.

New Ocean Record for the American Line.

The American liner St. Louis on her last trip reduced the ocean record from Southampton to New York from 6 days 5 hours 22 minutes, which was the time of her sister ship, the St. Paul, to 6 days 2 hours and 22 minutes. Her average speed was 20·86 knots an hour, which is slightly better than that of the St. Paul, which was 20·82. It is probable that to one of these fine ships will fall the distinction of being the first to bring the time of crossing below six days.

TRIAL OF THE COMPRESSED AIR MOTOR BY THE THIRD AVENUE RAILROAD COMPANY, NEW YORK.



SIDE VIEW OF ENGINES AND AIR BRAKE, HARDIE COMPRESSED AIR MOTOR.

THE HARDIE COMPRESSED AIR MOTOR CAR.

The compressed air motor is a device which is suffering from the prejudice engendered by many years of costly but comparatively fruitless experiment. Invention and capital, seeing its promising possibilities, have frequently joined hands in the effort to produce an efficient motor, but beyond learning some valuable lessons as to the chief sources of loss, and the direction in which improvement must be sought, they have failed to produce an effective machine.

At the present writing, interest in the compressed air motor has been revived by rumors of its adoption by two large corporations: the Metropolitan Traction Company and the Third Avenue Railroad Company, both of New York City; the former making use of the Hoadley motor, and the latter adopting the system invented by Mr. R. Hardie.

The trouble with the earlier systems has been of a twofold nature. When air was compressed into the storage reservoir, a certain portion of the power was expended in raising the temperature of the air (according to the well known law), and this heat, which was subsequently lost by radiation, represented a dead loss of power. Moreover, when the air was expanded in the cylinders, there was a corresponding reduction of temperature, which was often so great as to cause freezing and choking up of the exhaust passages.

In the Hardie system it is sought to prevent the first loss by compressing the air in three stages, and recovering the heat of compression by passing the air through tubes around which cold water is circulating. The cooling water is fed to the boilers and the heat which it has withdrawn from the compressed air is thus recovered. After passing the third stage of compression and cooling, the air is forced at a pressure of 2,000 pounds to the square inch into a reservoir consisting of a stack of rolled steel flasks, 9 inches in diameter and 20 feet long.

The cars, one of which is shown in the accompanying illustration, are similar in their general appearance to an ordinary street car; but they are provided with a truck whose construction is suggestive of the bar frame of a locomotive, the truck, moreover, being suspended by springs from the axle boxes, and the cars being similarly suspended from the truck. Underneath the seats and beneath the floor of the car are sixteen air reservoirs, similar to those in the power house. In the center of the car and also beneath the floor is placed a hot water tank, by means of which the air is heated before it enters the cylinders, and the difficulty of frozen exhaust passages is overcome. It is 18 inches in diameter and 7 feet long, and is filled with 500 pounds of water.

Before the car starts on its run, its air reservoirs are charged with cold air at 2,000 pounds pressure by means of a flexible tube connecting with the power house supply, and steam is admitted to the heater until its contents are raised to a temperature of 350 degrees. It takes a little over half a minute to charge the reservoirs.

In operating the car, the air is first expanded by a reducing valve to a pressure of 150 pounds, and passed into a receiving cylinder, whose capacity is one cubic foot. It is then admitted to the heater, where its action is thus described by General Herman Haupt, the consulting engineer of the company: "When the air passes into the tank of water heated to 350 degrees, each 50 cubic feet of air absorbs and carries over an amount of water in the shape of steam equivalent to 26 cubic feet of air. This adds 50 per cent to the volume; and, as the air is itself expanded 50 per cent by the increase of temperature, the total gain of volume as the air and steam pass from the heater is 100 per cent. The condensation of the steam in the cylinders and pipes liberates the latent heat and maintains the temperature at such a point as to render freezing impossible."

General Haupt informs us that the efficiency of the